STAFF/ENROLLMENT EXPLORATION SYSTEM: MODELING COST-INCOME FLEXIBILITY FOR FLORIDA COMMUNITY COLLEGES

BY

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It is both ironic and fitting that one of the highest academic achievements for the individual, the completion of a doctoral dissertation, comes after the diligent work and support of so many.

Accordingly, there are many persons who deserve a heartfelt acknowledgement for their untiring efforts in behalf of this work. Unfortunately, space does not permit mention of all. Therefore, the following is most certainly incomplete.

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TABLE OF CONTENTS

Page

ACKNOWLEDGMENTS iii

ABSTRACT vii

CHAPTER

I. INTRODUCTION 1

The Problem 5
Statement of the Problem 5
Limitations 7
Justification for the Study 7
Definitions 8
Procedures 10
Phase I--Specification of Objectives 11
Phase II--Review of Systems Operations 11
Phase III--Collection of Data 11
Phase IV--Analysis of the Data 11
Phase V--Isolation of the Problem 12
Phase VI--Specification of Operations 12
Phase VII--Construction of the Block Diagram (Equation) 12
Phase VIII--Validity and Evaluation 12

II. REVIEW OF GENERAL SYSTEMS OPERATIONS: REVIEW OF RELATED LITERATURE 14

Introduction 14
General Systems Theory 15
Isomorphism and Holism: Two Basic Assmuptions . . 16
System: The Central Construct 20
Open and Closed Systems 20
Entropy 23
Steady-State 23
Negentropy 25
Feedback 26
Equifinality 27
Systems Analysis 29
Modeling 32
Simulation 35
Management Information Systems (MIS) 37
Cost Analyses 40
Evaluation 49

Page

III. MODEL DEVELOPMENT 51

Introduction 51
Review of Key Systems Operations. 51
General 51
Specific 54
Collection of Data 54
Analysis of the Data 55
Isolation of the Problem 56
Specification of Operations 57
Construction of the Block Diagram (Equation) 57
Validity and Evaluation 61
Panels of Experts 61
Field Test Evaluation 62
Theoretical Monitor 63
SEES: Informational Outputs 63
Solution Set Tables 63
Graphs 69

IV. EVALUATION 74

Introduction 74
College Responses 74
Performance 74
Utility 75
Time 77
Cost 77
Discussion of the Responses 78

V. SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS FOR FURTHER RESEARCH. 80

Introduction 80
Summary 80
Implications. 81
Recommendations for Further Research. 82

APPENDIX

A DOCUMENTATION 84

B LETTER TO INSTITUTIONAL RESEARCH OFFICERS CONCERNING MODEL EVALUATION 98

C EVALUATION OF STAFF/ENROLLMENT EXPLORATION SYSTEM (SEES) 99

REFERENCE NOTES 102

REFERENCES 103

BIOGRAPHICAL SKETCH 107

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In this study constructs associated with simulation, modeling, management information systems (MIS), cost analyses, and evaluation were synthesized into a planning model for modeling cost-income flexibility in Florida community colleges. As a corollary, a methodological outline for the synthesis of planning models in general was developed.

The planning model, Staff/Enrollment Exploration System, was developed, validated, and evaluated through application of systems analysis. The systems analysis was conducted according to steps recommended by Banghart. The steps were supplemented through the addition of a step to establish validity and to provide evaluation.

After the objectives of the study were set and an extensive review of general systems operations was completed, three Florida community colleges were selected for a review of specific systems operations. Data were collected from several sources and were analyzed through use of an existing simulation model, Budget Simulator. This led to the isolation of the specific constructs needed to solve the problem. Once these constructs

were identified, operations were specified, data elements for the model were determined, and the logical and mathematical relationships among the data elements were developed. These relationships were programmed for computer assistance. This led to the prototype model.

The final model was validated by submitting the prototype model to a three-step process in which panels of experts reviewed the model for face and content validity.

Once the model was completed, data from each of the participating institutions were introduced to the model to produce tables of staff and enrollment solution sets to balance the institutions' budgets. In addition, graphs of the relationship between full-time equivalent part time faculty change to balance the budget as a function of enrollment were produced. This, plus installation of the software in each of the three colleges, provided the basis for evaluation of the model according to criteria associated with performance, utility, time, and cost.

The overriding implication of the study was that planning models and methodologies could be developed through application of general systems theory and systems analysis. In other words, theory could be translated into practice; systems research paradigms could be developed and applied to management and planning efforts in Florida community colleges.

In conclusion, general and specific recommendations for further research concerning general systems theory and applications were noted.

CHAPTER I

INTRODUCTION

> Modern science is characterized by its ever-increasing specialization, necessitated by the enormous amount of data, the complexity of techniques and of theoretical structures within every field. This, however, has led to a breakdown of science as an integrated realm: The physicist, the biologist, the psychologist and the social scientist are, so to speak, encapsulated in a private universe, and it is difficult to get word from one cocoon to the other. (Bertalanffy, 1956, p. 1)

In the late-1970's, given declining enrollments and threats of reduced support, new and difficult problems confront the educational administrator (Purga, 1979). Not only must decision-making processes be improved, but new ways of increasing informational inputs to those processes must be developed. Science must not only be advanced along specialized paths in search of highly detailed knowledge, but also departmentalized blinders must be removed in order to take advantage of the knowledge available across all fields of scientific endeavor. In other words , a major thrust of science must be the integration of knowledge.

Such integration is theoretically, and even pragmatically, possible despite barriers of jargon and academic provincialism, although these barriers are certainly impressive. Integration is possible through a common theoretical framework--general systems theory. Hearn (1958), stating the beliefs of general systems theorists, summarized the point:

> General systems theorists believe that it is possible to represent all forms of animate and inanimate matter as systems; that all forms from atomic particles through

> atoms, molecules, crystals, viruses, cells, organs, individuals, groups, societies, planets, solar systems, even the galaxies, may be regarded as systems. They are impressed by the number of times the same principles have been independently 'discovered' by scientists working in different fields. They are also disturbed by the waste which thus occurs when scientists have remained isolated within their own scientific spheres. They believe that the unification of theory in the physical and non-physical world is desirable and ultimately attainable, at least to some degree. Accordingly, they contend that there are properties which are common to systems of every order, although manifest in different forms, and that there are universal laws which describe the structure of systems and their manner of functioning. (p. 38)

Through the use of such an integrating theory, educational administrators can advance their knowledge in three ways. First, much can be learned through study and application of knowledge developed in other disciplines. Second, as general systems theory is heuristic, much can be learned through application of systems logic. And finally, much can be learned through the study and application of general systems concepts, constructs, and operations.

By following a systems perspective, the problems of declining enrollments and reduced support can be understood and solutions to these problems can be found. Thus, the problem can be restated as declining matter-energy inputs causing stress to the system. Using Miller's (1965a) classification, the stresses constitute "lack stress" and "matter-energy lack" stress (p. 225). These stresses serve to disrupt the steady-state or dynamic equilibrium of the system. Moreover, "when resources level or decline in steady state, institutions must be cost effective; they will be held accountable and judged according to the efficiency with which resources are used" (Gilliland & Gilliland, 1978, p. 8). An additional problem may be that "support by society for

universities, as we traditionally view them, may decline in steady state" (Gilliland & Gilliland, 1978, p. 8). An equally plausible outcome may be that the educational system collapses, particularly if the institution already tends toward entropy.

Just as the problem can be understood from a systems perspective, solutions can also be approached from a systems perspective. Entropy can be minimized in open systems by appropriate feedback channels. In fact, negentropy may be created which, by definition, reverses the tendency toward maximum disorder. Beyond this theoretical remedy is a closely related remedy--the logical relationship between informational inputs and negentropy as detailed by Bertalanffy (1956) and Miller (1965a). Accepting Hall and Fagen's (1956) definition of inputs as matter, energy, and information, one could reason that if there is a reduction in matter and energy inputs, a proportional increase in informational inputs may somewhat balance the loss. This relationship is especially apparent if one accepts a definition of steady-state which assumes a necessary but not sufficient requisite that the inputs be constant in the aggregate (Daly, 1977; Gilliland & Gilliland, 1978).

While the foregoing properly puts the problem and remedies in perspective, a caution is evident. General systems theory is holistic; i.e., the whole is greater than the sum of its parts. Educational systems are so permeable that it is often difficult to determine where the boundary of one system ends and another begins. Thus, many systems directly interface with educational systems. For example, political systems interface with educational systems in such a way that determination of the boundary of one system may be found <u>within</u> the other

system. This interaction creates complexity in the guise of multivariate interaction. The point is that complexity often forces researchers to hold many multivariate relationships constant when in reality they are not constant; holding them constant prejudices the findings. Of course, a balance must be struck between complexity and simplicity along the grounds of pragmatic research possibilities. Even the most complex models represent only a slice of reality, and, as such, are simplified. The goal is to deal with as much of the complexity as possible.

Unfortunately, even with this understanding, the complexity of systems often dissuades even the most ardent researcher. However, inroads have been made, departure points defined, and tools developed. Increasingly sophisticated computer technologies and mathematical applications, in concert with a systems perspective, are allies in the integration of knowledge. And, as information increases in quantity and quality, solutions to once difficult problems can be found. Guba (1975), commenting on the systems approach to evaluation, optimistically addressed the possibilities:

> Such an approach is epitomized in systems theory; a system is devised which has face validity for responding to assessed needs, and which is then through successive empirical iterations perfected until it is responsive. Indeed, infinite perfectability, to use a theological concept, seems well within reach, if the number of iterations is large enough. (p. 50)

Given modern computer technology, a large number of iterations is possible.

Fortunately, this approach to the integration of knowledge is more than theoretical. It is also methodological and thus can be applied.

Systems analysis, defined generally by Banghart (1969) as the "utilization of scientific mathematical techniques applied to organizational operations as part of management's decision-making activities," is such a methodology (p. 20). Among these "scientific mathematical techniques" are constructs associated with simulation, modeling, management information systems (MIS), cost analyses, and evaluation. And, one way to increase informational inputs to decision-making is to synthesize these constructs into planning models.

The Problem

Statement of the Problem

The problem of the study was to synthesize the constructs associated with simulation, modeling, MIS, cost analyses, and evaluation into a planning model for modeling cost-income flexibility in Florida community colleges. A corollary problem was to develop a methodological outline for the synthesis of planning models in general.

Resolution of the problem was accomplished through application of systems analysis according to the logical sequence of steps recommended by Banghart:

1. Establish Objectives
2. Review of Systems Operations
3. Collection of Data
4. Analysis of Data
5. Isolation of the Problem
6. Specify Operations in the Problem Area
7. Block Diagram (Logical relationships among subsystems) (1969, pp. 29-41)

In addition to Banghart's steps, a step for establishing validity and for performing evaluation was developed. As an integral part of the study, the model was evaluated using modifications of criteria first discussed

by Banghart (1969, pp. 42-46) and later more fully developed by the Academy for Educational Development (Note 1):

> 1. Performance. How effective is the system in providing needed answers? How appropriate is it to stated needs? How well does it reflect institutional policy?
>
> 2. Utility. How useful is the system? How often will it be used and how many people will participate in its application? Is it flexible enough to accept major changes in organizational structure?
>
> 3. Time. What is the time required for installation? How much time is required for collecting base data necessary to operate the system? What is the time required to retrieve information?
>
> 4. Cost. Is the value of the information worth the cost of implementation? Will it save money in terms of time and personnel? Is a model really needed at current costs? (p. 27)

These generalizable criteria were modified to reflect the specifics of the problem statement of this study as outlined in Phase VIII in the procedures section of the present chapter. Moreover, since it is theoretically correct to define one form of evaluation as a formalized process which provides information concerning a system's operation compared to the system's desired operation, these evaluative criteria, expressed in statement form, served to set functional objectives for the model itself. Specifically:

1. Performance. The model would effectively answer questions related to cost-income flexibility. It would meet institutional needs to model cost-income flexibility. It would relate institutional policy to cost-income flexibility.

2. Utility. The model would be useful. It could be used routinely. It would adapt to institutional change.

3. Time. The time for installation would be minimal. The time required for data collection would be minimal.

4. Cost. The information would be worth the cost; institutions would be willing to purchase the planning model.

Limitations

1. The rules and definitions of the model were designed to meet the needs of Florida community colleges.

2. Due to equifinality in open systems, rules, definitions, and certain operations may change over time.

3. Costs and incomes are defined solely in terms of dollars. More subjective costs and incomes are not considered.

Justification for the Study

Through the methodological extension of general systems theory, systems analysis, informational inputs to the decision-making process could be increased in an attempt to minimize entropic tendencies caused by stress. More specifically, given uncertainty due to fluctuating enrollments and funding levels, synthesis of constructs associated with systems analysis into a planning model for modeling cost-income flexibility would make a contribution to the management and planning efforts of Florida's community colleges.

The model would be heuristic; knowledge concerning systems analysis methodology would be advanced. Theory could be translated into practice through the development of a methodological outline for the synthesis and evaluation of planning models in general. Knowledge that existed in other disciplines would be integrated through the cognitive processes of synthesis and evaluation (Bloom, 1966). Both the model and the methodological outline could be applied by others to develop yet other planning models.

This study would also contribute to a series of research studies undertaken by the Florida Community Junior College Inter-Institutional

Research Council (IRC). The IRC membership was interested in the development of planning models for determining cost-income flexibility in educational systems.

Definitions

Boundary. That "region where greater energy is required for transmission across it than for transmission immediately outside that region or immediately inside it" (Miller, 1965a, p. 214). For the social group, can be defined "in terms of the amount and intensity of interactions among members" (Hearn, 1958, p. 42).

Closed system. A system in which there is no exchange of materials, energies or information with its environment.

Cost. Measured in dollars, any expenditure by an educational system.

Cost-income flexibility. Refers to a relative degree rather than to an absolute point, the administrative ability to allocate resources through alternative policy measures. Flexibility increases as alternatives increase.

Entropy. "The disorder, disorganization, lack of patterning, or randomness of organization" (Miller, 1965a, p. 196).

Equifinality. The ability of open systems to achieve identical results from unequal initial conditions.

Evaluation. A formalized process which provides information concerning a system's operation compared to the system's desired operation.

Faculty productivity ratio. Total number of fundable units produced by an institution divided by the total number of full-time equivalent instructional personnel.

Feedback. In systems, "the property that a portion of . . . outputs or behavior is fed back to the input to affect succeeding outputs" (Hall & Fagen, 1956, p. 37).

Full-time equivalent (FTE). For instructional staff, "equates to a standard faculty workload of 42 credit hours of instruction for the academic year." For all other personnel, "252 days per year and a normal workweek (usually 37.5 or 40 hours)" (Community College Management Information System Procedures Manual, 1977, pp. 6.14-6.15).

Holism. The notion that in a system "there is at least one measure of the sum of its units which is larger than the sum of that measure of its units" (Miller, 1965a, p. 201).

Income. Measured in dollars, any resource to the educational system.

Isomorphism. Commonly called parallelism in social science literature, refers to (1) "one-to-one correspondence between respective elements of . . . sets, and (2) certain structures of . . . sets are preserved" (Hill & Kerber, 1967, p. 14).

Model. With isomorphism existant, "a representation of some subject of inquiry (e.g., objects, processes, systems) to be utilized for purposes of controlling predictions and decision-making" (Hill & Kerber, 1967, p. 15).

Negentropy. Opposite of entropy, "toward states of increased order and organization" (Bertalanffy, 1956, p. 4).

Open system. A system in which there is exchange of materials, energies, or information with its environment.

Simulation. A model "which depicts the workings of a large scale system of men, machines, material and information operating over a period of time in a(n) . . . environment representative of actual real world conditions" (Malcolm, 1963, p. 417).

Steady-state. A "constant ratio among components of the system" (Hearn, 1958, p. 44).

Subsystem. "The totality of all the structures in a system which carry out a particular process" (Miller, 1965a, p. 218) and "keeps one or more specific variables in steady-state" (Miller, 1965b, p. 338).

Suprasystem. The next higher system relative to the system in question.

System. Simply, "a set of objects together with relationships between objects and between their attributes" (Hall & Fagen, 1956, pp. 18-19). Operationally a community college.

Systems analysis. Generally, "utilization of scientific mathematical techniques applied to organizational operations as part of management's decision-making activities" (Banghart, 1969, p. 20).

Procedures

The study was conducted in eight phases following Banghart's (1969) steps to systems analysis (pp. 29-41).

Phase I--Specification of Objectives

This was the express purpose of the present chapter, and, even more particularly, the purpose of the statement of the problem.

Phase II--Review of Systems Operations

This phase was conducted in a general and specific mode. The general mode involved an extensive review of the literature concerning general systems theory, systems analysis, modeling, simulation, MIS, cost analyses, and evaluation. This review set the theoretical basis for the study and identified relevant constructs associated with methodological techniques. The specific mode involved a review of actual institutional operations at three Florida community colleges. These colleges, hereafter referred to as College A, College B, and College C, were chosen on the basis of their interest and willingness to participate. College A was a large multi-campus system. College B was a mid-size, single campus system. College C was a small, rural, single campus system.

Phase III--Collection of Data

The collection of data involved review of existing and potential data sources. Included in this phase was a review of the Community College Management Information System (CCMIS).

Phase IV--Analysis of the Data

The analysis of the data was accomplished through use of an existing fiscal simulation model, Budget Simulator (Nickens, 1977). Data collected in Phase III were used to provide analysis.

Phase V--Isolation of the Problem

The analysis resulted in a clear understanding of the specific constructs necessary to resolve the more general problem of the study.

Phase VI--Specification of Operations

The specific data elements required for the model were determined.

Phase VII--Construction of the Block Diagram (Equation)

The logical and mathematical relationships among the data elements were developed. These relationships were programmed for computer assistance.

Phase VIII--Validity and Evaluation

In a three-step process, panels of experts reviewed the model for face and content validity. An evaluation was performed wherein data from Colleges A, B, and C were introduced to the model to produce tables of staff and enrollment solution sets. In addition, graphs of the relationship between full-time equivalent (FTE) part time faculty change to balance the budget and enrollment were produced. This, plus installation of the software in each of the three colleges, provided the basis for evaluation of the model according to the following criteria:

1. Performance. Did the model effectively answer questions related to cost-income flexibility? Did it meet institutional needs to model cost-income flexibility? How well did it relate institutional policy to cost-income flexibility?

2. Utility. How useful was the model? Could it be used routinely? How well did it adapt to institutional change?

3. Time. How much time was necessary for installation? How much time was required for collecting the data base necessary to operate the system?

4. Cost. If you had sufficient funds and were not able to receive installation . . . , how much would you be willing to pay for the model and its installation on your computer?

Answers to these questions were provided by the Directors of Institutional Research and the chief finance officer or appropriate budget officer at each of the colleges. A narrative discussion of these evaluations was presented.

CHAPTER II

REVIEW OF GENERAL SYSTEMS OPERATIONS: REVIEW OF RELATED LITERATURE

Introduction

In order to review general systems operations and to clarify the logical and theoretical relationships upon which this study was built, several areas of scholarly study were explored in some detail. More specifically, the following areas are covered in Chapter II: general systems theory, systems analysis, modeling, simulation, MIS, cost analyses, and evaluation.

Several data bases were reviewed. Seven key words contained or implied in the proposal title (cost, income, evaluation, flexibility, model, planning, and systems) were researched thoroughly in the Dissertation Abstracts International from the year 1861 through June, 1979. The search was conducted to discover supporting studies and to determine a measure of originality for the proposed study. Numerous abstracts and dissertations were studied; only several were of use to the proposed study and none threatened originality. Additionally, a computer search by several keyword descriptors was completed using the Educational Resources Information Center (ERIC). This search also yielded some pertinent information but was largely disappointing, as very few references provided useful information. In short, although an extensive review of the literature and literary data bases was undertaken, the yield of useful literature, particularly with regard to

procedural questions, was sparse. This situation further underscored the need for more research in this area.

General Systems Theory

As the theoretical advances of administration are studied, it is clear that theory, in the form of general systems theory--the "Skeleton of Science" (Boulding, 1956)--presents an integration of the past theoretical milieu. Kast and Rosenzweig's (1974) conception of the sociotechnical organization consisting of five subsystems (goals and values, psychosocial, structural, technical, and managerial) provided an excellent example of this integrative utility:

> Traditional management theory emphasized the structural and managerial subsystems and was concerned with developing principles. The human relationists and behavioral scientists emphasized the psychosocial subsystem and focused their attention on motivation, group dynamics, and other related factors. The management science school emphasized the technical subsystem and methods for quantifying decision-making and control processes. Thus each approach to organization and management has tended to emphasize particular subsystems, with little recognition of the importance of the others. The modern approach views the organization as an open, sociotechnical system and considers all the primary subsystems and their interactions. (p. 113)

Thus, general systems theory is not different from other theories; it actually contains other theories and provides a way to put theory in perspective, not in conflict.

As the inter-discipline and cross discipline integration of theory is accomplished, the heuristic nature of general systems theory allows broad derivations of theory and fosters the advance of knowledge through the use of analog models across disciplines. For example, Hill (1967) cited how "the biological theory of cell growth could be used as analog

model for social growth" (p. 17). Likewise, mathematical or symbolic models can be applied to organisms and organizations through general systems' concepts and constructs. In order to do this, however, one must carefully build a firm theoretical foundation to underpin methodology and isomorphic conclusions. If, for example, one's conception of the boundary of a cell is faulty as it relates to openness and closedness, then one's isomorphic conclusions regarding social boundaries vis-a-vis growth are also apt to be faulty. Thus, one should be careful to build a solid foundation before one assumes isomorphic transferability. The following discussion of the basic concepts and constructs of systems theory serves to provide the theoretical foundation for the study.

Isomorphism and Holism: Two Basic Assumptions

One of the basic assumptions underpinning general systems theory is isomorphism, "a one-to-one correspondence between objects which preserves the relationships between the objects" (Hall & Fagen, 1956, p. 24). Hill (1972) detailed the logic implicit in isomorphism:

> Another basic concept of model theory involves isomorphism. The study of logic shows that two sets are isomorphic if the following two conditions are satisfied: (1) a one-to-one correspondence exists between the respective elements of the sets, and (2) certain structures of the sets are preserved. If two sets are found to be isomorphic, then either may serve as the model for the other. For example, a miniature automobile is a model of an actual car if it is isomorphic to the real one; for every detail in the body design of the actual automobile there is a corresponding detail in the miniature's body design. In other words, a one-to-one correspondence between the respective elements of the sets exists.
>
> In addition, the state of isomorphism requires that certain structures be preserved between the two sets. For example, if the automatic transmission gearshift lever is located on

> the steering column of the actual car, it must be similarly located and constructed to scale in the miniature version. Although the miniature car is a model of the actual automobile in this example, the opposite could be true because they are isomorphic sets--that is, the actual car could be the model of the miniature automobile. (p. 14)

While Hill's examples might lead one to the faulty conclusion that isomorphism and "identity" are one in the same, isomorphism does not imply the existence of an absolute identity. Bertalanffy (1956) qualified this point:

> The isomorphy we have mentioned is a consequence of the fact that, in certain aspects, corresponding abstractions and conceptual models can be applied to different phenomena. It is only in view of these aspects that system laws will apply. This does not mean that physical systems, organisms and societies are all the same. In principle, it is the same situation as when the law of gravitation applies to Newton's apple, the planetary system, and the phenomenon of tide. This means that in view of some rather limited aspects a certain theoretical system, that of mechanics, holds true; it does not mean that there is a particular resemblance between apples, planets, and oceans in a great number of other aspects. (p. 2)

Isomorphism (or parallelism) assures the integrated or inter-disciplinary nature of general systems theory. Without this assumption the theory is logically vacant. With this assumption, general systems theory is charged with the potential to become truly grand theory.

Perhaps oversimply, holism is expressed most understandably as the whole is greater than the sum of its parts. Miller (1965a), paraphrasing Bertalanffy's (1956) definition of a system "as a set of units with relationship among them" (p. 200), reasoned that "set" implies units that have common properties: "Moreover, there is at least one measure of the sum of its units which is larger than the sum of that measure of its units" (p. 201).

Holism is central to the epistemology inherent in organismic biology and Gestalt psychology, and is directly related to functionalism. According to Kast and Rosenzweig (1974),

> its basic emphasis is upon systems of relationships and the integration of parts and subsystems into a functional whole. Functionalism attempts to look at social systems in terms of structures, processes, and functions and attempts to understand the relationship between these components. It emphasizes that each element of a culture or social institution has a function in the broader system. (p. 113)

Thus, holism obviously transcends disciplines.

Holism is actually a philosophic construct. Its roots are found in the earliest metaphysics. Although its position of favor has fluctuated through time due to the limitations and advantages of other modes of thought vis-a-vis the perceived advancement of knowledge, it has, in the late-1970's, achieved a preeminence with respect to its utility for science. Bertalanffy (1956), discussing the conditions leading to the rise of inter-disciplinary theories, cited the controversy between mechanists and vitalists as leading close to the "bankruptcy of science" (p. 12). Further, Bertalanffy specified that a leading cause of this scientific dead end (primarily in physics) was science's inability to proceed beyond linear causal models to multivariate models. Bertalanffy (1956) summed the problems presented by this dead end thusly:

> In the biological, behavioral and sociological fields, there exist predominant problems which were neglected in classical science or rather which did not enter into its considerations. If we look at a living organism, we observe an amazing order, organization, maintenance in continuous change, regulation and apparent teleology. Similarly, in human behavior goal-seeking and purposiveness cannot be overlooked, even if we accept a strictly behavioristic

> standpoint. However, concepts like organization, directiveness, teleology,etc., just do not appear in the classic system of science. As a matter of fact, in the so-called mechanistic world view based upon classical physics, they were considered as illusory or metaphysical. This means, to the biologist for example, that just the specific problems of living nature appeared to lie beyond the legitimate field of science. (p. 12)

Certainly the social scientist too puzzles over the nagging concern that his science does not or could not fall into the "legitimate field of science." In less professional and more parochial settings this question continues to consume disproportionate amounts of energy.

Bearing these assumptions in mind, an examination of the aims, beliefs, and definitions of general systems theory reveals the hollowness of the legitimacy question and presents the framework of a truly unified approach to science. Bertalanffy (1956) listed the aims of general systems theory:

> Aims of General Systems Theory
>
> Summarizing, the aims of General Systems Theory can be indicated as follows:
>
> (a) There is a general tendency towards integration in the various sciences, natural and social.
>
> (b) Such integration seems to be centered in a general theory of systems.
>
> (c) Such theory may be an important means for aiming at exact theory in the non-physical fields of science.
>
> (d) Developing unifying principles running 'vertically' through the universes of the individual sciences, this theory brings us nearer to the goal of the unity of science.
>
> (e) This can lead to a much-needed integration in scientific education. (p. 2)

System: The Central Construct

Bertalanffy (1956) defined system as "sets of elements standing in interaction" (p. 3). Churchman, (1968) offered "a set of parts co-ordinated to accomplish a set of goals" (p. 29). The most complete definition of system was offered by Hall and Fagen (1956): "A system is a set of objects together with relationships between objects and between their attributes" (pp. 18-19). As necessary, Hall and Fagen continued by defining objects, attributes, and relationships. Objects were defined as "the parts or components of a system" (p. 18). Attributes "are properties of objects." The following examples of attributes were offered:

> atoms--the number of planetary electrons, the energy states of the atoms, the number of atomic particles in the nucleus, the atomic weight.
>
> stars--temperature, distances from other stars, relative velocity. (p. 81)

Relationships "tie" the system together. It is in fact relationships that make the notion 'system' useful. An extremely important point here is the implication that if objects can be identified, attributes and relationships can be measured.

Open and Closed Systems

The basic (and classic) typology is open and closed systems. Open systems interact with their environments; closed systems do not. Hall and Fagen (1956) made this distinction:

> Most organic systems are open, meaning they exchange materials, energies, or information with their environments. A system is closed if there is no import or export of energies in any of its forms such as information, heat, physical materials, etc.,

> and therefore no change of components, an example being a chemical reaction taking place in a sealed insulated container. An open system becomes closed if ingress or egress of energies is cut off. (p. 23)

Before examining this typology further, it is appropriate to discuss several terms introduced above. Environment was defined by Hall and Fagen as "the set of all objects a change in whose attributes affect the system and also those objects whose attributes are changed by the behavior of the system" (1956, p. 20). Moreover, the exchange of materials (matter), energy, and information occurs as inputs (ingress) and outputs (egress). Figure 2.1 presents an example of a simple model of an open system.

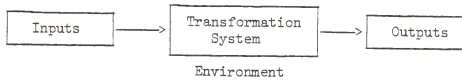

Figure 2.1. Simple Open System (Adapted from Kast and Rosenzweig, 1974)

Moreover, an additional concept is implied above. Boundary distinguishes the system from the environment. Miller (1965a) defined the boundary "as that region where greater energy is required for transmission across it than for transmission immediately outside that region or immediately inside it" (p. 214). Hearn (1958) defined boundary in a slightly different way, a way more applicable to social systems; "the boundary of a group can be defined in terms of the amount and

intensity of interactions among members" (p. 42). Hearn concluded with an important observation concerning how boundary is defined:

> Both methods are essentially the same in that the critical value which is used to demarcate the system from its environment is an arbitrary designation. Thus, the boundary of a system has reality and utility merely as a concept in the mind of the beholder. (p. 42)

As boundaries are more permeable, i.e., more matter, energy, and information flows between the system and environment, the system is considered to be more open. In fact, most theorists have agreed that no system is entirely closed; all boundaries are at least slightly permeable. Thus, the distinction between open and closed systems is more a matter of degree of openness rather than of absolutes of being either open or closed.

Continuing with a discussion of the typology, Bertalanffy (1956) presented a well-developed distinction between open and closed systems:

> My first example is that of closed and open systems. Conventional physics deals only with closed systems, that is, systems which are considered to be isolated from their environment. Thus, physical chemistry tells us about the reactions, their rates, and the chemical equilibria established in a closed vessel where a number of reactants is brought together. Thermodynamics expressly declares that its laws only apply to closed systems. In particular, the second principle of thermodynamics states that, in a closed system, a certain quantity, called entropy, must increase to a maximum, and eventually the process comes to a stop at a state of equilibrium. The second principle can be formulated in different ways, one being that entropy is a measure of probability, and so a closed system tends to a state of most probable distribution. The most probable distribution, however, of a mixture, say, of red and blue glass beads, or of molecules having different velocities, is a state of complete disorder; having separated all red beads on one hand, and all blue ones on the other, or having, in a closed space, all fast molecules, that is, a high temperature on the right side, and all slow ones, a low temperature, at the left, is a highly improbable state of affairs. So the tendency towards maximum entropy or the most probable distribution is the tendency to maximum disorder.

> However, we find systems which by their very nature and definition are not closed systems. Every living organism is essentially an open system. It maintains itself in a continuous inflow and outflow, building up and breaking down of components, never being, so long as it is alive, in a state of chemical and thermodynamic equilibrium but maintained in a so called steady state which is distant from the latter. This is the very essence of that fundamental phenomenon of life which is called metabolism, the chemical processes within living cells. (p. 3)

Several concepts alluded to by Bertalanffy require attention.

Entropy

"The tendency to maximum disorder," is expressed in the second law of thermodynamics which states,

> Even though there is an equivalence between a certain amount of work and a certain amount of heat, yet in any cyclic process, where a system is restored to its original state, there can never be a net conversion of heat into work but the reverse is always possible. (Miller, 1965a, p. 195)

Miller continued by defining entropy as, "The disorder, disorganization, lack of patterning or randomness of organization" (p. 196). Entropy is a natural property of all closed systems; open systems, that is, systems interacting with their environments, may tend towards entropy or may maintain a steady state or may even possess negentropy.

Steady-State

Only open systems can maintain a steady-state or dynamic equilibrium. Hearn (1958) described steady-state as a "constant ratio among components of the system" (p. 44). Hearn stated further, "The composition of the system is independent of, and maintained constant in a varying import of materials" (p. 44). Miller (1965a) outlined the relationship between steady-state (dynamic equilibrium) and equilibrium in the following example:

> When opposing variables in a system are in balance, that system is in equilibrium with regard to them. The equilibrium may be static and unchanging or it may be maintained in the midst of dynamic change. Since living systems are open systems, with continually altering fluxes of matter-energy and information, many of their equilibria are dynamic and are often referred to as flux equilibria or steady states. These may be unstable, in which a slight disturbance elicits progressive change from the equilibrium state--like a ball standing on an inverted bowl; or stable, in which a slight disturbance is counteracted so as to restore the previous state--like a ball in a cup; or neutral, in which a slight disturbance makes a change, but without cumulative effects of any sort--like a ball on a flat surface. (p. 224)

A mid-range postulate reflected by most general systems writers is that open systems tend toward a steady-state. Hearn (1958) simply stated, "After any disturbance, a system tends to re-establish a steady-state" (p. 44).

A mention of disturbance or stress is warranted in order to understand fully the concepts of equilibrium and steady-state. Miller (1965a), postulating a range of stability for systems, referred to four types of stress.

> Lack stress. Ordinarily there is a standard range of rates at which each sort of input enters a system. If the input rate falls below this range, it constitutes a lack stress.
>
> Excess stress. If the input rate goes above this range, it is an excess stress.
>
> Matter-energy stress. There are various ways for systems to be stressed. One class of stresses is the matter-energy stresses including: (a) matter-energy input lack or underload--starvation or inadequate fuel input; (b) input of an excess or overload of matter-energy; and (c) restraint of the system, binding it physically.
>
> Information stress. Also there are information stresses, including: (a) information input lack or underload, resulting from a dearth of information in the environment or from improper function of the external sense organs or input

> transducers; (b) injection of noise into the system, which has an effect of information cut-off, much like the previous stress; (c) information input excess or overload. Informational stresses may involve changes in the rate of information input or in its meaning. (p. 225)

Miller concluded with an application of Le Chatelier's principle in closed and open systems;

> Le Chatelier (1888, p. 200) stated his principle, which applies to nonliving systems and possibly also to living systems, as follows:
>
> Every system in chemical equilibrium undergoes, upon the variation of one of the factors of the equilibrim, a transformation in such a direction that, if it had produced itself, would have led to a variation of opposite sign to the factor under consideration. A common statement of it is: A stable system under stress will move in that direction which tends to minimize the stress. (p. 225)

Thus, systems react to stress with the minimum activity necessary to reduce stress. This postulate in concert with the postulate that open systems tend toward a steady-state explain much of observed system behavior; they could explain the apparent sluggishness of some systems in response to changed inputs.

Negentropy

Negentropy or negative entropy is closely related to the concept of information (Miller, 1965a). This relationship was detailed by Bertalanffy (1956):

> The general notion in Communication Theory is that of information. Information is measured in terms of decisions. Take the game of Twenty Questions, where we are supposed to find out an object by having answered questions about it by yes or no. The amount of information conveyed in one answer is a decision between two alternatives, such as animal or non-animal. With two questions, it is possible to decide for one out of four possibilities, for example, mammal--non-mammal, or flowering plant--non-flowering plant. With three questions it is a decision out of eight, and so forth. Thus, the logarithm at the basis 2 of the possible

> answers can be used as a measure of information, the unit being the so-called binary unity or bit. The information contained in two answered questions is $\log_2 4 = 2$ bits, of three answers, $\log_2 8 = 3$ bits, and so forth. This measure of information happens to be similar to that of entropy or rather negative entropy, since entropy also is defined as a logarithm of probability. But entropy, as we have already heard, is a measure of disorder; hence negative entropy or information is a measure of order or of organization since the latter, compared to distribution at random, is an improbable state. In this way information theory comes close to the theory of open systems, which may increase in order and organization, or show negative entropy. But negative entropy can be considered a measure of decisions, taken out of equally probable ones, a measure of improbability or information. (p. 5)

In sum, open systems not only tend toward steady-states but may also tend toward negentropy--"Toward states of increased order and organization" (Bertalanffy, 1956, p. 4).

Feedback

Closely related to negentropy is the concept of feedback. Figure 2.2 represents a simple, open system with a feedback loop.

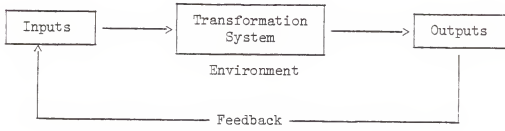

Figure 2.2. Simple Open System with Feedback Loop

Feedback was simply defined by Hall and Fagen (1956):

> Certain systems have the property that a portion of their outputs or behavior is fed back to the input to affect succeeding outputs. (p. 87)

Weiner (1954) defined feedback as "the property of being able to adjust future conduct by past performance" (p. 33). Feedback is an important process for the maintenance of steady-states and, moreover, may be a necessary process for the production of negentropy given the increase in information to the system.

There are two basic kinds of feedback, positive and negative. Negative feedback provides the favorable process described above. In short, negative feedback allows the system to be self-regulating (Hearn, 1958, p. 47). Simply, negative feedback allows the system to readjust to inappropriate outcomes or outputs by informing the system of the inappropriate behavior through information inputs.

Positive feedback is disadvantageous to the system because it merely reinforces behavior and does not allow for system adjustment. Following Kast and Rosenzweig's (1974) definition of negative feedback as "informational input which indicates that a system is deviating from a prescribed course" (p. 126), positive feedback can be defined as informational input which indicates that a system is not deviating from a prescribed course. The consequences for a system having only positive feedback structures are predictable. If change is indeed inevitable then adjustment and readjustment are equally inevitable.

Equifinality

Equifinality, which occurs only in open systems, is an important concept in general systems theory. Bertalanffy (1956) detailed what is meant by equifinality:

> The first is the principle of equifinality. In any closed system, the final state is unequivocally determined by the initial conditions: for example, the motion in a planetary system where the positions of the planets at a time t are unequivocally determined by their positions at a time t_0. Or in a chemical equilibrium, the final concentrations of the reactants naturally depend on the initial concentrations. If either the initial conditions or the process is altered, the final state will also be changed. This is not so in open systems. Here, the same final state may be reached from different initial conditions and in different ways. This is what is called equifinality, and it has a significant meaning for the phenomena of biological regulation. Those who are familiar with the history of biology will remember that it was just equifinality that led the German biologist Driesch to embrace vitalism, that is, the doctrine that vital phenomena are inexplicable in terms of natural science. Driesch's argument was based on experiments on embryos in early development. The same final result, a normal individual of the sea urchin, can develop from a complete ovum, from each half of a divided ovum, or from the fusion product of two whole ova. The same applies to embryos of many other species, including man, where identical twins are the product of the splitting of one ovum. Equifinality, according to Driesch, contradicts the laws of physics, and can be accomplished only by a soul-like vitalistic factor which governs the processes in foresight of the goal, the normal organism to be established. It can be shown, however, that open systems, insofar as they attain a steady state, must show equifinality, so the supposed violation of physical laws disappears. (p. 4)

Hearn (1958) believed that equifinality is, "Closely related to the concept of steady-state . . . which simply means achieving identical results from different initial conditions" (p. 44). Conversely, there is the implication that different results may be achieved from identical initial conditions. This implication remained to be discussed in the literature to this date.

Kast and Rosenzweig (1974) related the importance of equifinality for social systems and organizations:

> The equifinality of social systems has major importance for the management of complex organizations. The closed-system cause and effect relationship adopted from the

> physical sciences would suggest that there is one best way to achieve a given objective. The concept of equifinality suggests that the manager can utilize a varying bundle of inputs into the organization, can transform these in a variety of ways, and can achieve satisfactory output. Extending this view further suggests that the management function is not necessarily one of seeking a rigid optimal solution but rather one of having available a variety of satisfactory solutions to his decision problem. (p. 119)

Given the element of uncertainty inherent in conditions which allow identical outcomes with different inputs and, accepting the converse, different outcomes from identical inputs, the critical importance of ongoing negative and positive feedback structures is clearly apparent. Moreover, given equifinality in educational systems coupled with stresses created by declining matter and energy inputs, the need to increase information to educational systems is clear. And, one way to increase information is through systems analysis.

Systems Analysis

Systems analysis is based on the belief that objects can be identified and their attributes and relationships can be measured and thus analyzed. Banghart (1969) defined systems analysis generally as involving "utilization of scientific mathematical techniques applied to organizational operations as part of management's decision-making activities" (p. 20). Thus, systems analysis describes a process of analysis as well as techniques of decision-making to use as tools in the process. This process is presented in a flow chart in Figure 2.3. In this figure, the step of validation was added to a flow chart adapted from Banghart (1969, p. 38). Banghart (1969) further provided a series

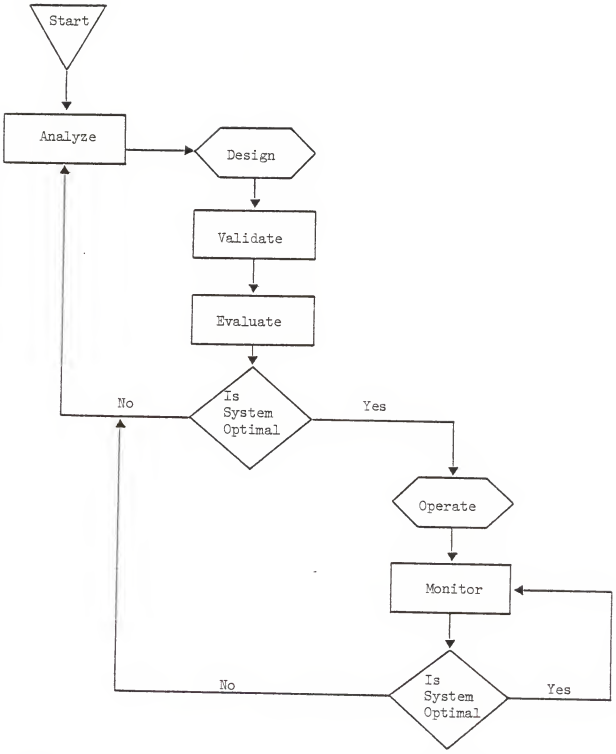

Figure 2.3 A Systems Analysis Flow Chart (Adapted from Banghart, 1969, p. 38)

of procedural guidelines under which systems analysis should be conducted:

> Step One--Establish Objectives.
> Step Two--Review of Systems Operations.
> Step Three--Collection of Data.
> Step Four--The Analysis of Data.
> Step Five--Isolation of the Problem.
> Step Six--Specify Operations in the Problem Area.
> Step Seven--Block Diagram (Logical relationships among subsystems) (pp. 39-41)

Systems analysis is a methodology. It is therefore a process which increases information. And while classical statistics (usually probability theory) may be utilized, systems analysis differs with respect to classical experimental design. This is a critical point. Banghart (1969) addressed the point in this way:

> Analysis of data is discussed separately from collection of data in order to point out the distinction between a systems analysis and the traditional experimental paradigm in research. The experimenter in the social sciences has generally followed the model of the physicist. That is, his experiment involves a dependent and an independent variable. Manipulation of the independent variable is followed by systematic measurements made upon the dependent variable. In classical fashion cause and effect relationships are studied and determined. This type of classical experimental paradigm, however, assumes that the investigator knows in advance specifically which variables are to be controlled and investigated. In a systems analysis one begins the analysis with the objective of determining just which variables are relevant. Where the classical experimenter is concerned with manipulation of variables in the dependent and independent sense, the analyst is concerned with a study dealing with interaction of many variables. Causality is not necessarily the primary concern. Correlation becomes the primary concern. (Emphasis added) (p. 40)

In this way, an object's attributes and relationships are studied in a systematic way to increase information. It would appear that the validity and power of this approach are just as compelling as the validity and power of the classical experimental design. Of course,

the most apparent difference is the generalizability of results. However, systems analysis as a procedure or method based in general systems theory is broadly generalizable. Moreover, generalizability has been found across certain variables with regard to organizational size (Coombs & Hallak, 1972; Halstead, 1974, p. 245). Perhaps as more attention is turned to this area of research, more generalizable factors will be discovered. In any case, uncertainty and complexity often preclude an experimental approach but not a systematic, if piecemeal approach:

> The environment of higher education as it affects program budgeting is characterized, as are most social systems, by uncertainty, complexity, and elements that defy measurement. Uncertainty--the inability to fully understand all outcomes--arises because all objectives relevant to educational programs can never be accounted for nor can changes in policy or advances in technology be accurately predicted. . . . Usually a piecemeal approach is necessary: studying parts of a problem and reporting partial answers. (Halstead, 1974, p. 653)

Systems anslysis insures a systematic, theoretically sound approach to complexity and uncertainty, even if subsystems must be studied more or less in a piecemeal way. Of course, subsystem interrelatedness is not ignored, it is considered as fully as complexity allows.

Systems analysis as a process or method has been discussed. As mentioned, systems analysis also refers to some specific techniques. The techniques and constructs pertinent to this study are discussed below.

Modeling

A basic concept of general systems theory is that of isomorphism. As modeling theory is grounded in general systems theory, isomorphism is central to modeling theory and in fact defines what is meant by the notion of modeling:

> The Basic Concept of a research model is that of isomorphism. The science of logic states that two sets are isomorphic if the following two conditions are satisfied: (1) there exists a one-to-one correspondence between the respective elements of the sets, and (2) certain structures of the sets are preserved. These two conditions are necessary if isomorphism of the sets is to exist. (Hill & Kerber, 1967, p. 14)

As mentioned in the discussion of general systems theory, it would be faulty to conclude that isomorphism and identity are one and the same. Rather than identity, symmetry is sometimes mentioned as an additional property of isomorphism. However, as is apparent in Bertalanffy's argument, symmetry may not be considered a necessary condition of isomorphism to the employment of a model. This is particularly true if a great deal is known about an area to be used as a model and the model is used to "suggest theory or laws for an area about which comparatively little is known"(Hill & Kerber, 1967, p. 14). Thus, a perfect identical and symmetrical relationship is not absolutely necessary although the more identity and symmetry present, the more valid and reliable the conclusions made about one system based on manipulations of the model. Hill and Kerber (1967) summed the logic presented here and provided an understanding of the utility of modeling:

> Viewed in its broadest sense, a scientific model might be thought of as a representation of some subject of inquiry (e.g., objects, processes, systems) to be utilized for purposes of controlling predictions and decision-making. Based upon the definition of a model in terms of isomorphism, it should be obvious that if the laws and theory of one discipline are isomorphic with the laws and theory of another discipline, either one of the 'sets' may be used as the model (representation) of the other. We also know that if isomorphism is considered to exist between two disciplines, the laws and theory of the more familiar discipline may be used as a model to suggest laws and theory for the comparatively little-known discipline. Thus, the set chosen as the model mainly serves

> an explanatory purpose, and facilitates the discovery of how alterations in certain aspects of its components affect certain other aspects of the set, or how these alterations affect the total system. In short, the model is manipulated to determine effects of change, rather than imposing the changes directly on, or over, the system of the subject of inquiry itself. (p. 15)

There are three basic types of models: iconic, analog, and symbolic or mathematical. Hill and Kerber defined these three types:

> (1) the iconic model is a pictorial or physical representation of certain parts of, or the total, system under inquiry. A photograph, or our earlier illustration of the model automobile, are good examples of iconic models;
> (2) the analog model is a diagram, flow chart, or a similar type of representation resulting from employing the properties of a familiar system to represent those of the system under inquiry; where the 'sets' of properties of the respective systems are considered to be isomorphic. The previous example of the study of electricity by means of employing the properties of the then more familiar field of hydrodynamics is a good example of analog model utilization;
> (3) the symbolic model is a 'formula' representation resulting from the employment of symbols to designate properties of the system under study. A good example of the symbolic model is the mathematical equation, or set of equations, which represents the problem situation under study. The symbolic model is employed in those cases where the laws and theory of mathematics, or symbolic logic, are isomorphic with the laws and theory of the system under inquiry. (1967, p. 15)

Hill and Kerber noted that these characteristizations are general and that "precise definition and discussion of the relationships that might exist between respective types have been purposely omitted" (1967, p. 15). Certainly, complexity could be introduced here by way of a discussion of symbolic logic and formal semantics but this discussion is not pertinent to this study and would, moreover, "becloud the basic understanding of the term 'model'" (Hill & Kerber, 1967, p. 15).

Model development is obviously a challenging procedure given the isomorphic constraints. Following the systematic logic of general systems

and modeling theory, steps must be formulated in order to assist in model development. Banghart (1969) identified some recommended steps:

> Step 1. Define the problem in specific terms such that the problem lends itself to quantitative labeling.
>
> Step 2. Construct a flow chart such that all steps in the model are clearly detailed.
>
> Step 3. Collect preliminary data that are adequate for purposes of plotting.
>
> Step 4. Graph the data.
>
> Step 5. Determine the problem form of the equation from the graph.
>
> Step 6. Test the derived equation for accuracy and predictability. (p. 235)

In sum, model theory enables the construction of isomorphic systems which provide for understanding of a related system. For example, one cannot afford in any way to manipulate the parameters associated with a "real" organization without unduly causing change within that organization. Or, more simply, it may be impractical or impossible to do so. However, if one can construct a model of the system or its subsystem and manipulate the model, theory and laws may be derived and tested with no damage to the integrity of the original system. In this way modeling is related to simulation.

Simulation

Malcolm (1963) defined a system simulation project as,

> One which depicts the workings of a large scale system of men, machines, material and information operating over a period of time in a simulated environment representative of the actual real world conditions. A simulation project generally utilizes an electronic computer and may operate in 'real' time or in compressed time where the simulated system may be operated for several years in but a few hours of computer time. (p. 417)

This definition offers several key elements critical to an understanding of simulation. First, the connection between simulation and model is apparent as one "cannot conduct a simulation without first building a model of the system" (Banghart, 1969, p. 235). Second, simulations generally involve the use of computers which enables rapid transformation of data. Third, simulations allow "real time" management by utilizing the rapid transformation of data to model situations, which normally would take years to model, "in but a few hours of computer time." This last point is salient for the study and points to the value or utility of simulation. Moreover, the use of "real-time" decision-making relates to the critical difference between formative and summative evaluation which will be discussed later in this review.

Many simulation examples exist. Ivey (1977) described several including Resource Requirements Prediction Model 1.6 (RRPM), Comprehensive Analytical Methods of Planning in University/College Systems VIII (CAMPUS), System for Evaluating Alternative Resource Commitments in Higher Education (SEARCH), Temple University Planning Model (TEMPLAN), Planning Translator II (PLANTRAN), and Budget Simulator (pp. 21-25). Banghart (1969) discussed several simulation cases (pp. 249-253). The point here is that numerous simulations have been developed and are available from a variety of sources; it is not necessary to develop a new model in many instances. In educational administration one only needs to contact a few sources for simulation models: Most notably The University Council for Educational Administration, The National Council for Higher Education Management Systems, and the Florida Community Junior College Inter-Institutional Research Council (IRC) at the University of Florida.

All simulation models utilize the theory base presented thus far. Most follow the logic of the Budget Simulator (Nickens, 1977); several points are important here. First, data from the system's most recent fiscal period is required to develop baseline cost relationships. Second, the simulation is built upon a program-cost center relationship. This structure enables budget objects to be analyzed by program and by cost center which allows interfacing with management information systems (MIS).

Management Information Systems (MIS)

Management information systems (MIS) refers to a concept and an "orientation toward which an information system design moves rather than being an absolute state" (Davis, 1974, p. 7). Since MIS is not an absolute state, it is somewhat difficult to define what exactly is meant by MIS. And, for the same reason, the lack of an absolute state, it is increasingly important to define MIS. Unfortunately, most definitions in the literature do not illuminate the difference between MIS and just another information system--an important difference if one is to attempt to design a MIS. To point, Enger (1969) offered the following definition:

> A management information system is a management-oriented system characterized by information elements structured into a data base serving the information requirements of policy and operating management. (p. 14)

This definition offers little beyond self-evident definition. Most other definitions one finds are equally vague. Thus, another approach to understanding the concept of MIS is to examine critical elements which may differentiate MIS from simple information systems.

Three such elements are real-time management, computer assistance, and decision-making support. Real-time management refers to management

in concert with ongoing events. The distinction between formative and summative evaluation clarifies the point. Formative evaluation occurs throughout all stages of a program with feedback occuring constantly. Summative evaluation occurs at the conclusion of the program. If decisions are to be made in real-time, then the process must be formative. In order to accomplish this, computers are often needed for their rapid information turnaround capabilities as well as their abilities to store large amounts of data. Real-time management is virtually impossible unless computer assistance is available--an MIS is impossible without computer assistance. Finally, MIS is utilized to aid decision-making by management. Information systems not utilized for decision-making support are not MIS. To make the point further, if information gathered in MIS is not utilized in decision-making, the title MIS is inappropriately applied.

These elements also characterize what MIS is supposed to do. In short, MIS is to provide management with a real-time mode of information processing which supports decision-making. The use of computers allows this and, also, allows the utilization of complex mathematical and statistical models to further sharpen decision-making capabilities.

Another approach to understanding MIS is to look at its history. Davis (1974) maintained that MIS grew from developments in four areas: managerial accounting, management science, management theory and computer processing (p. 8). In a sense, MIS can be thought of as a marriage of these fields. Additionally, the growth of systems analysis and general systems theory have had obvious implications for MIS. MIS certainly draws upon all of the techniques of systems analysis--

cost-analysis, simulation, linear programming, gaming theory, modeling, along with imaginative use of statistics. In the late-1970's, MIS is still unfolding as contributions from other disciplines and theories continue to add to MIS sophistication and capabilities.

MIS promises quite a bit if one looks at its definition and functions. Unfortunately, MIS has not always delivered results equal to its promise. In the introduction to American Council on Education (ACE) and Western Interstate Commission for Higher Education (WICHE) publication Management Information Systems: Their Development and Use in the Administration of Higher Education, Minter and Lawrence (1969) identified several problems associated with MIS. These points are paraphrased into general and specific problems:

General

1. Cost--was it worth the cost to collect and analyze the data?
2. Could the problem bearing analysis be properly identified?
3. Many MIS designs sprang from decentralized information systems which already existed. Therefore, coordination was fragmented.
4. Lack of communications existed between developers of the system and users of the system.

Specific

1. Managers continued to use intuitive judgement.
2. Managers maintained "hidden agendas" with regard to system-wide objectives.
3. Lack of resources to develop, test, and implement MIS.
4. Lack of qualified personnel.
5. Industrial models did not fit educational models.

While these problems are pervasive they are not unsolvable. Some solutions may be fairly clear while others may be more difficult. In most cases, the problems were a function of misunderstandings and misapplications of a still evolving concept. The advantages of MIS, particularly given retrenchment and retooling, justify that careful attention be given to solution of these problems. Of particular pertinence to this study are the MIS components related to cost analyses and cost-based financing methods.

Cost Analyses

Cost-based financing methods. Martorana and Wattenbarger (1978) examined state community college financing methods and concluded, in a subjective evaluation, that a cost-based method is best suited, overall, to provide the most effective and flexible resource allocation. Perhaps the chief difference between a cost-based method and a more traditional unit-rate method is the degree of sophistication associated with the data analyses required to determine relationships between costs. For example, "one of the strong outcomes of cost-based funding is a more precise management-information system and a set of definitions of programs, cost allocations, and accounting procedures" (Martorana & Wattenbarger, 1978, p. 23). The outcomes described above are also requirements for effective cost-based funding methods; MIS, common program definitions, and accurate data collection procedures are necessary for cost analyses which are central to cost-based funding.

In the late-1970's Florida employed such a cost-based financing process for community colleges (Florida's Community Colleges State-Level Resource Acquisition/Allocation Process, Note 2). The process was based

upon data generated through the Cost Analysis, a yearly series of reports which were part of Florida's Community College Management Information System (CCMIS) (Community College Management Information Procedures Manual, 1977, pp. 6.1-6.39). The process, which could be expressed as a formula, was as follows:

> Using a series of enrollment reports and projections submitted by the colleges, the staff of the Division of Community Colleges determines the number of FTE students which are expected to enroll in each field of study in each college; such as Biological Studies, Mathematics, Health Occupations, Trade and Industrial Occupations. Based upon guidance and priorities which have been established by the Department of Education or may have been provided by the Legislature, the number of students to be funded in each field of study at each college is determined. The Director of the Division of Community Colleges recommends and the Commissioner of Education assigns the number of full-time equivalent student enrollments to each community college for purposes of allocating the Community College Program Fund (CCPF). After the enrollments are assigned, the allocation of the dollars can be made.
>
> The cost analysis for the previous year is used to determine the state-wide average cost per FTE, and the ratio of the cost per FTE for each field of study is calculated. By multiplying the State cost on which the appropriation is based times the cost ratio of each field of study times the number of assigned FTE in each field of study the allocation for each college can be determined. State Board of Education Rules allow adjustments to be made for size differentials, salary schedules, regional cost variables and other factors which are necessary to maintain programs and financial stability. (Florida's Community College State-Level Resource Acquisition/ Allocation Process, Note 2, pp. 7-8)

This approach to cost-based financing of community colleges represented one attempt to account for educational cost behaviors and relationships. Even so, there remained several weaknesses inherent to the process (Baker & Ellis, Note 3). Therefore, before discussing pertinent educational cost behaviors and relationships, a review of cost analysis techniques is in order.

Cost analysis techniques. While at first glance, cost analysis techniques seem to be well defined, in actuality, various labels and definitions are afforded cost analysis techniques, viz., cost-utility analysis, cost-benefit analysis, cost-effective analysis, and rate-of-return analysis.

While other variants of these themes are found and, although sometimes the labels are regretfully interchanged, these four labels constitute the major approaches used in cost analysis. In fact cost-utility analysis, cost-benefit analysis, and rate-of-return generally refer to the same construct, i.e., (1) attaching a value or gain per unit cost and, (2) determining the best use given value among several alternative decisions (Coombs & Hallak, 1972; Woodhall, 1970; Beeby, 1970). The difference in conception is slight but important. Basically, cost-utility is a more generalized term which encompasses any approach linking costs and value (Banghart, 1969). Cost-benefit analysis is usually expressed in ratio form while rate-of-return "is simply the rate of interest that equates the discounted present value of expected benefits and the present value of the cost of the project" (Woodhall, 1970, p. 23). As noted the distinction is slight but does serve to clarify the use of closely related terms. Cost-effective analysis, while used in the same vein by some (Banghart, 1969), by including value, more generally refers to the costing of alternative plans with or without value considered. Or, a simpler notion of cost-effectiveness is to insure that a program is at least generating enough revenue (resources) to cover what it consumes. This approach to cost-effectiveness, while attractive in its simplicity, requires careful model design as educational "products" do not generate

revenue to be fed back into the educational system. However, educational outputs do input resources into the suprasystem, i.e., society, and as such can be considered from a cost-effective or even cost-benefit framework (Coombs & Hallak, 1972).

Although there exists some confusion over the differentiation of these terms (confusion more academic than of practical significance), most analyses use these approaches with varying degrees of satisfaction. Obviously, there are problems inherent to these approaches. The most pressing is the assignment of value or utility. This is possibly the greatest objection of most educators to the application of cost analyses to education. Simply, our skills of quantification are not nearly so sophisticated as to allow firm quantification of values even if consensus could be reached concerning the priority of values. Thus, cost analyses of this kind are usually unreliable and are changeable by socio-economic and political factors. There exist other objections as well. Woodhall (1970) discussed several including:

1. Interrelation between ability and education.
2. Relation between earnings and productivity.
3. Spill-over benefits of education.
4. Effect of unemployment on rates of return.
5. Relation between the present and the future.
6. The meaning of the private rate of return. (pp. 25-34)

There may be other objections; one may be that the focus, due to theoretical construction, has been on inputs and outputs and not specifically upon process or structural relationships. Coombs and Hallak (1972), discussing the broadening of planning functions and its chief tool, cost analysis, clarified this point:

> But this is just the point; the boundaries must be widened. To serve the present urgent need for educational systems to change and renew themselves in virtually

> every respect, the previous conception of educational planning must be broadened still further to include the planning of internal changes in these systems. (p. 60)

Several notable attempts at planning internal changes have been developed in Florida. McCabe (Note 4) discussed several cost analysis systems in use at Miami-Dade Community College. These systems combined enrollment, staff, and productivity measures to plan for internal changes. Miner (1976) specified the basic relationship between costs and income for evaluation purposes, i.e., the total, assuming costs are expressed as negatives, should be greater than or equal to zero. Given this relationship, equations, using cost and income elements, could be written and solved for any element. From this basic perspective, relationships among elements could be cast in algebraic terms in order to model actual cost behaviors and relationships. This process could be programmed for computer assistance for simulation and modeling purposes. However, the basic behaviors and relationships must first be studied before any attempt at symbolic modeling could be made.

Educational cost behaviors. Coombs and Hallak (1972) related the most basic and key point for educational cost analyses models:

> the behavior of costs is strikingly similar in virtually all educational systems. This is due not only to the influence of certain economic principles at work everywhere but also to the fact that educational systems the world over operate on the basis of quite similar fundamental technologies, logistics, underlying pedagogical premises, and conventional wisdom. These have a profound influence on the economics of education, so much so that changing the behavior of costs is likely to require changing some fondly-held beliefs and practices. (p. 109)

Thus, generalizability is enhanced across educational systems; state systems can generalize certain behaviors across component subsystems.

in the absence of this generalizability, model building simply cannot take place. Several of these common behaviors are discussed below.

The single most important cost behavior is the dominance of personnel costs (Coombs & Hallak, 1972, pp. 109-110). In the terms of the economist, education is a labor-intensive industry. That is, other than in a few instances (most notably television), modern technology has not benefited education in guise of increased productivity. Coombs and Hallak reported further that personnel costs in various countries ranged from a low of 52% of current costs in Argentina to a high 98% in Morocco (p. 166). Additionally while not found in the literature, a principle generally accepted by many administrators is that personnel costs should not exceed 80% of the operating budget. It is not unusual for institutions to reach this limit rather quickly--many institutions are finding difficulty living within this ratio. Thus, personnel costs represent the largest variant affecting total system cost.

Coombs and Hallak also pointed out that unit costs, irrespective of inflation, seem to be rising (pp. 111-112). A related point is that costs are greater at higher levels (pp. 112-113). The implication is that, all other things held constant, costs will not remain constant. As costs rise, pressures for increased efficiency also rise.

One key to improving efficiency is to identify and take advantage of economies-of-scale (Coombs & Hallak, 1972, pp. 114-118; Halstead, 1974, pp. 271-278). In this regard, a comprehensive study of costs and potential economies was undertaken at the University of Bradford in 1972 to attempt to answer many of these questions (Bottomley, 1972). It appears that the variables associated with the greatest economies-of-scale are

student/faculty ratios, class size, and enrollment--which are obviously interrelated (Bottomley, 1972; Halstead, 1974, p. 273; Race, 1974). The problem here is, of course, how to determine the thresholds of these economies-of-scale.

Finally, Coombs and Hallak pointed out that educational cost structures are remarkably stable:

> While it is true that dynamic changes are constantly taking place in educational costs, the broad structure within which they occur shows some stability over time. Judging from the evidence available, the heavy proportion of teacher inputs relative to non-teacher recurrent inputs and capital inputs appears to have changed little, if any, over the years. For example, Blaug shows that salary costs in British universities had the same percentage relation to total costs in 1962 as in 1952. . . . The stability of educational cost structures reflects primarily the stability of educational technologies and practices and the hidden assumptions on which they are founded--such as the assumption that class size and the pupil-teacher ratio is the most critical determinant of how much is learned. Considering the great economic size and social importance of educational enterprises today, and their evident need to re-examine old premises and search for new practices, there has been remarkably little investment in research and development aimed at improving their performance. Until this neglect is corrected, there is every reason to expect educational cost structures to continue on their customary course, and for education--good or bad--to become increasingly expensive. (p. 112)

This stability among cost structures, along with the generalizability discussed above, is a requisite for modeling educational systems. If costs behaved differently in different educational systems, the model building requirement of isomorphism could not be met.

So far the focus of this section has been on the behavior of costs as they relate to one another or behave in general. Costs may also be studied in terms of their variability. This variability is also related to economies (diseconomies)-of-scale. For example, as enrollments increase, equipment depreciation may remain fixed. Thus, more resources

(FTE generated revenue) are available without proportional increases across all cost objects. Baker and Ellis (Note 3), following a study of Florida's funding system by Touche-Ross & Co., presented the following definitions of fixed, semi-variable and variable costs to the 1978 annual meeting of the Southern Association of College and University Business Officers (SACUBO):

> FIXED COSTS--Costs which typically do not vary with changes of enrollments within the 'normal range' of operations.
>
> VARIABLE COSTS--Costs which typically vary directly with changes of enrollments.
>
> SEMI-VARIABLE COSTS--Costs which typically vary somewhat with changes of enrollments within the 'normal range' of operations. (p. 8)

Please note the reference to the "normal range" of operations. The implication is that costs may vary if "normal operations" are drastically changed. More, specifically, Baker and Ellis pointed out that "a college's fixed support costs tended to remain constant until the total student enrollment changed by 50%, at which point a distinct change in the total funding for support costs occurred" (1978, p. 9). This fact may allow models to treat support costs as being relatively fixed.

Baker and Ellis continued by classifying costs according to cost categories. Please refer to Table 2.1. Obviously the most variable costs are associated with instructional costs and supplies and services. However, Lyell (1977) found that faculty salaries were becoming more and more fixed, i.e., less subject to variation regardless of enrollment patterns. Thus, faculty costs may not be variable in declining enrollments and may remain constant rather than adjust to new enrollment patterns.

Table 2.1

Cost Variability in Florida Community Colleges

Cost Category	Direct Cost of Instruction			
	A & P	Occup.	Devel.	CIS
Personnel Costs				
Instructional	V[a]	V	V	V
Administrative	SV	SV	SV	SV
Support Staff	SV	SV	SV	SV
Non-Personnel Costs				
Supplies, Services	V	V	V	V
Equipment Depreciation	F	F	F	F

	Support Costs			Plant Operations and Maintenance
	Academic Support	Student Support	Institutional Support	
Personnel Costs				
Exec., Admin., Managerial	F	F	F	F
Non-Instructional Professional	F	F	F	F
Support Staff	SV	SV	SV	F
Non-Personnel Costs				
Supplies and Services	SV	SV	SV	F
Equipment Depreciation	F	F	F	F

[a]Codes: F = fixed costs; V = variable costs; SV = semi-variable costs.

Adapted from Baker and Ellis, 1978 (Note 3).

A final requirement for cost analysis and model development is the existence of common cost category definitions. In Florida, several approaches to this requirement existed. First, the community college system operated under a common accounting system adapted in large measure from the groupings recommended in Financial Accounting: Classifications and Standard Terminology for Local and State School Systems (Roberts & Lichtenberger, 1973). Second, as noted, there existed common definitions in the Cost Analysis (Community College Management Information System Procedures Manual, 1977, pp. 6.1-6.39). In any case, data bases existed which could be used to provide common definitions.

Evaluation

Evaluation is implied in the foregoing both in terms of the utility of systems analysis and in terms of evaluation of the techniques of systems analysis themselves.

The major distinction in evaluation (and in the context of the study) is the difference between formative and summative evaluation (Guba, 1975). Formative evaluation occurs as the subject-object evolves and thus allows for change based on evaluative input before the process is complete. Summative evaluation occurs at the conclusion of the process and thus allows change only in the next process cycle. Most evaluations occur in the summative mode.

The importance here is that for "real-time" management to take place, formative evaluation is necessary. Thus, simulation, as discussed, supports formative evaluation. While an advantage of summative evaluation is that all the real data are collected prior to evaluation, often the evaluation comes too late to provide meaningful results.

Formative evaluation allows for corrective action before the worst case becomes reality. In either context, evaluation is essential to the organization as it provides both positive and negative feedback.

It is also important to evaluate the techniques and procedures used to do the evaluation of the systems analysis. Banghart (1969) posited that any such evaluation include questions concerning performance, cost, utility, and time (pp. 42-46). Similarly, the Academy for Educational Development, citing a 1972 study by Jerome F. Wartgon, listed the same basic questions for the evaluation of simulation models.

> 1. Performance. How effective is the system in providing needed answers? How appropriate is it to stated needs? How well does it reflect institutional policy?
>
> 2. Utility. How useful is the system? How often will it be used and how many people will participate in its application? Is it flexible enough to accept major changes in organizational structure?
>
> 3. Time. What is the time required for installation? How much time is required for collecting base data necessary to operate the system? What is the time required to retrieve information?
>
> 4. Cost. Is the value of the information worth the cost of implementation? Will it save money in terms of time and personnel? Is a model really needed at current costs? (Academy for Educational Development, Note 1, p. 27)

It is clear that the techniques themselves must be evaluated, for too often the performance, utility, time, and cost may not justify the increased information--and then again it may show that the information increase was far more valuable than the investment of resources. Additionally, refinement is always possible. Given change and equifinality, refinement may be a necessity.

CHAPTER III

MODEL DEVELOPMENT

Introduction

Since the model was developed through application of systems analysis, this chapter is organized according to the logical sequence of steps regarding systems analysis as recommended by Banghart (1969, pp. 39-41). Moreover, since the corollary problem of this study is to outline, through application, a methodological blueprint for model building in educational systems, and since the objectives were set in Chapter I and general systems operations were reviewed in Chapter II, the outline is completed in Chapter III.

Accordingly, the following procedural steps are covered in Chapter III: review of key systems operations, collection of data, analysis of data, isolation of the problem, specification of the problem, and construction of the block diagram (equation). In addition, sections dealing with validity and evaluation, and informational outputs of the model are included.

Review of Key Systems Operations

General

General principles concerning educational systems' operations were developed through an extensive literature review in Chapter II. Several of the key ideas are presented in this section.

The most basic idea is that the behaviors of educational systems can be understood through application of general systems theory. This idea leads to the notion that entropy can be retarded or reversed in open systems by increasing informational inputs. It then follows that one way of increasing informational inputs is to utilize the methodological arm of general systems theory, systems analysis. And, since systems analysis depends not only upon systematic thinking but also upon cross- and inter-disciplinary approaches, study and development of the constructs associated with modeling, simulation, MIS, cost analysis, and evaluation were warranted. Therefore, several points regarding modeling and cost analysis are discussed in the next paragraphs; key points regarding simulation, MIS, and evaluation (validity) are made in the following sections as appropriate.

With regard to modeling and cost analysis, Coombs and Hallak (1972) had pointed out that educational costs behave similarly in virtually all educational systems; moreover, these cost relationships were stable over time (p. 109). Similarity of behavior enhances generalizability while stability enhances isomorphic parallels. And, generalizability and isomorphism are basic requisites for model building.

Several other more specific cost behaviors in educational systems were found to be important for model building. First, personnel costs dominated institutional operating budgets (Coombs and Hallak, 1972, pp. 109-110). This fact, coupled with the fact that most indirect costs in Florida's community colleges were relatively fixed (Baker & Ellis, Note 3), clearly suggested that the prime focus of planning models should be personnel costs. It was apparent that the greatest economies and flexibility may be achieved

in the direct instructional personnel categories. In fact, the greatest economies and flexibility were found in the administrative allocation of course sections to part time faculty. This was true in that part time faculty were paid much less per FTE instructor than FTE full time faculty and part time faculty were not under contractual obligation to teach more than a single course. Simply, if the enrollment in a course was not cost effective, the course was not taught.

Another important point was the fact that all educational costs did not vary directly with enrollment fluctuations (Baker & Ellis, Note 3). It was therefore highly desirable to allow for treating costs behaviors as being not only variable in relation to enrollment but also semi-variable or fixed in relation to enrollment.

So far, the discussion has centered upon the behavior of educational costs. Some attention to educational incomes is in order. All that is necessary for model building is the existence of a funding system which can be symbolically modeled. Since Florida utilized formula funding based on enrollments as discussed in Chapter II, it was possible to model expected system incomes. In fact, formula funding in cost-based systems is an attempt to model costs so that costs and income will match, i.e., theoretically balance to zero. Thus, the existence of formula funding in a cost-based system facilitated higher level model building as income elements can be easily specified.

It is clear, to this point, that not only is there a theoretical basis for attempting to model educational systems' costs and incomes, but also that conditions necessary for modeling were present in educational systems.

Specific

Once these general systems operations were reviewed and noted, a more specific review was undertaken in order to validate the general principles and to determine additional field conditions which might contribute to the overall systems analysis. To accomplish this, the fiscal subsystems of three Florida community colleges were reviewed. These colleges are referred to as College A, College B, and College C.

This review included in-depth discussions with the institutional budget and planning officers regarding the points gleaned from the literature and regarding specific system's behaviors and operations. In short, these persons were asked to substantiate and add to, from a practitioner's perspective, the findings from the literature review. In the judgement of the practitioners, all of the general points were valid for the individual institutions.

In addition, this review led to a better understanding of the needs and concerns of the potential users of the final model. The most important of these needs and concerns was that the data collection requirements be minimal. Attention to this led to the next step in the systems analysis.

Collection of Data

The data collection step involved a review of institutional data sources and data required through the Community College Management Information System (CCMIS). In order to determine facility of collection and relevance of information to cost-income flexibility, each data source was studied relative to the data requirements of an existing fiscal simulation model, Budget Simulator (Nickens, 1977). In all instances, practitioners

were consulted regarding their perceptions of the availability and accuracy of existing data sources. Emphasis was placed on existing data sources as opposed to creating a need to generate new data bases.

Once the review of the data sources was completed, and several promising sources were identified, an analysis of the data was undertaken.

Analysis of the Data

The analysis was accomplished by using several data sources in an attempt to drive Budget Simulator. In each case, the objectives, as specified in Chapter I, were carefully considered, as a means of evaluation. Furthermore, several runs of Budget Simulator were made to explore cost and income relationships.

At this point in the analysis, it was hoped that Budget Simulator could be used as an integral part of the final model. Thus, these preliminary runs were conducted not only to determine cost-income relationships and the potential efficacy of each data source but also to test the feasibility of using Budget Simulator as part of the final model.

The results of this analysis, which led to the isolation of the problem, revealed several salient points. First, if the model was to have any generalizability, the data elements must have common definitions in each institution. This ruled out data collection based on institutional self-reports as there was considerable difference among the various institutional definitions even in a common accounting system. Second, Budget Simulator, while feasible for certain operations, could not be used to answer all questions concerning flexibility. For example,

Budget Simulator was not designed to yield future combinations of full time and part time faculty necessary to increase administrative flexibility and to balance the budget. Moreover, Budget Simulator did not allow for the linkage of enrollment, income, and costs in light of the fact that costs may be variable, semi-variable or fixed in relation to enrollment fluctuations. Finally, the data requirements necessary to drive Budget Simulator were found to be complex from an institutional perspective, thus limiting the attainment of the objective of minimizing the time necessary for data collection.

The third point made apparent by the analysis was that cost-income relationships do exist. And, most importantly, these relationships may be demonstrated through the use of simulation and modeling.

Isolation of the Problem

Attention to the implications of the results of the analysis indicated a need to develop a symbolic model which could be manipulated to show various combinations of full and part time faculty, in concert with all other costs, which balance future costs with future incomes. This symbolic model, to be useful for planning, had to allow for variations in cost element behaviors relative to enrollment and had to be driven by data elements with common definitions in all Florida community colleges. As the data requirements led to the advisability of using data available through the existing CCMIS, it became desirable to develop a model which was computer assisted, which could be used in real-time, and which could be related to decision-making.

In short, the problem of the study was refined to include some very specific requirements given the state of field operations taken within the context of the objectives of the study.

Specification of Operations

To this point, the salient operations necessary to meet both the general problem statement (Chapter I) and the more specific and refined requirements of the isolated problem have been reviewed. In order to proceed, it was necessary to specify the operations (data elements) required to meet the now rather specific needs.

This step was facilitated, of course, by the foregoing collection and analysis of data. Accordingly, it became apparent that the data available from the yearly Cost Analysis (Community College Management Information System Procedures Manual, 1977), and more specifically, the CA-2, would meet the data requirements for the cost elements (pp. 6.1-6.39). Since costs were reported by programs in the CA-2, this report was chosen to align the cost elements in the new model. Simply, the cost elements, with minor exceptions as noted in Appendix A, were defined in accordance with definitions found in the CA-2 (pp. 6.13-6.17).

The income elements included those elements which contributed to the funding formula: student semester credit hours, discipline weight, unitary FTE, tuition, and federal funds. A general element, "other", was added to account for special fees, auxiliary incomes, and gifts.

Construction of the Block Diagram (Equation)

The basic premise which led to an accurate expression of the logical relationships among the cost and income elements is that the sum of the

two kinds of elements should, in a public, nonprofit organization, equal zero. This being the case, it was possible to construct an equation which reflects this basic relationship between the cost and income elements where the cost elements are assumed to be negative:

$$0 = \Sigma I + \Sigma C$$

where: I = income elements

C = cost elements

Given this basic relationship and the mathematical relationships inherent in the community college funding formula in Florida, a complete equation could be written. The equation and data element definitions are given in Figure 3.1. As mentioned, the cost elements are defined in accordance with the CA-2 (Community College Management Information System, 1977, pp. 6.13-6.17). The income elements are defined in accordance with the funding formula (refer to pp. 40-41 in this study). Additionally, an "other" element was added to both the cost and income element lists in order to provide for costs or incomes not fitting the prescribed definitions. For more detail, refer to Appendix A.

Once the equation was constructed, it became possible to vary systematically the selected data elements while the balance was held constant. This yielded all possible combinations (solution set) of the systematically varied elements which balanced the equation. Unfortunately this resulted in virtually an infinite number of solution sets. However, by "targeting" an element to be calculated last, i.e., to be calculated to account for the necessary numerical adjustment to the constant, the number of solutions in the solution set was reduced to a more manageable number. Since most administrative flexibility was associated with part

$$O = \Delta A\left[\frac{BC}{30} + D\right] + E + F - [\Delta GH + \Delta IJ + \Delta KL + \Delta MN] - [O + P + Q] - [\Delta RS + \Delta TU + \Delta VW] - [X + Y + Z] - AA$$

where:

A = Student semester credit hours
B = Discipline weight
C = Unitary FTE
D = Tuition per credit hour
E = Federal funds
F = Other
G = Full time equivalent (FTE) full time faculty
H = Average salary-benefits FTE full time time faculty
I = FTE part time faculty
J = Average salary-benefits FTE part time time faculty
K = FTE administrative faculty
L = Average salary-benefits administrative faculty
M = FTE faculty support
N = Average salary-benefits FTE faculty support
O = Faculty supplies and services
P = Faculty capital outlay
Q = Faculty equipment replacement
R = FTE indirect administration
S = Average salary-benefits indirect administration
T = FTE indirect other professional
U = Average salary-benefits FTE indirect other professional
V = FTE indirect support
W = Average salary-benefits indirect support
X = Indirect supplies and services
Y = Indirect capital outlay
Z = Indirect equipment replacement
AA = Other
Δ = Elements to be systematically varied (added upon the completion of the logical development in this chapter)

Figure 3.1 Cost-Income Equation

time faculty and a common tactic in financial exigencies is to cut this personnel element before all others, this element was chosen as the element to be "targeted."

In addition, if the selected elements were varied within an unlimited range, the number of solutions, while not virtually infinite, still remained rather large. However, if ranges and steps were specified, the number of solutions was further decreased. This was not a problem in that typical ranges of variation (from a base) of all cost and income elements normally were minimal. For example, changes of more than 20% in any of the elements were highly unlikely; in most cases all possible changes were not of real interest but changes within intelligently specified ranges were of great interest. Moreover, since it was desirable to treat elements in terms of their behaviors, e.g., variable, semi-variable, or fixed in relation to enrollment, specification of such ranges and steps allowed this treatment. For example, a fixed behavior could be set by specifying a very narrow range, a semi-variable behavior could be set by specifying a little wider range and a variable behavior could be set by specifying a range as wide as the range set for the enrollment element.

Even with these adjustments to the equation two problems remained. First, there still would be an unmanageable volume of solutions if all 27 cost and income elements were systematically varied. Second, the calculations, if done manually, would take too much time to be of any real value. In order to reduce the number of solutions, it was decided that since personnel costs dominated the operating budget, only the personnel and the enrollment elements should be varied. And, in

order to provide rapid information in real-time, the equation and all the operations just described were programmed for computer assistance using Fortran IV.

The result of the systems analysis from the setting of objectives to this block diagraming was the prototype planning model and software, Staff/Enrollment Exploration System (SEES).

Validity and Evaluation

This step, while not specifically part of Banghart's recommended steps for systems analysis, is implied in his guidelines and, most importantly, is part and parcel of any level of systems thinking. In that an initial step in the creation of a cybernetic model is the establishment of the validity of the model and given that evaluation completes the feedback loop by reestablishing validity under changing conditions, this step was undertaken and is detailed in this section.

Panels of Experts

To establish face and content validity, the prototype SEES was submitted to five expert practitioners in the fields of management information systems (MIS), cost analysis, budgeting, and internal auditing.

From this critical review several enhancements to the prototype were recommended. Specifically, the need to account for fee waivers and the need to provide for specification of a balance for exploration purposes were noted. Accordingly, the prototype software was reprogrammed to allow input of a percentage reduction in expected fees due to fee waivers and to allow for a specified balance to the cost-income side of the equation.

Next, the prototype SEES was presented to the full membership of the IRC. One additional suggestion was made at this meeting: A faculty productivity ratio should be associated with each solution set so that users could determine whether any solution would result in unacceptable changes in the student/faculty ratio. The prototype software was reprogrammed to include a faculty productivity ratio which was defined as the ratio of total student semester credit hours to the total FTE faculty (SCH/FTE full time faculty + FTE part time faculty). In addition, the decision was made to allow input of limitation ranges for both the faculty productivity ratio and the FTE part time faculty so that solution sets which were beyond institutionally specified limits would not be printed.

Once these changes were made, full documentation (Appendix A) was written and installations were made at each of the IRC member colleges. In each case, a workshop involving the appropriate business and planning vice-presidents, deans, and their staffs was conducted to instruct these individuals in the use of SEES. This procedure not only served to "get SEES up" at the member institutions but also served as a final validity check for SEES.

This three-step review of SEES by over 40 expert practitioners served to validate the model.

Field Test Evaluation

In addition to the validation procedures, SEES was evaluated through the use of three institutional field tests. These three institutions, Colleges A, B, and C, were the same colleges wherein the initial studies

were conducted. In each case, relevant data for each college were collected and an analysis was performed using SEES. The results of this evaluation are presented in Chapter IV.

Theoretical Monitor

Since SEES was designed not only as a specific planning model to determine cost-income flexibility but was also designed as a methodological blueprint which might give rise to other constructs, there exists a built-in theoretical monitor consistent with systems logic. That is, as the model is used, its heuristic nature compels modification as time and conditions change. The basic question is, "Is the system optimal?" If the answer is yes, then no change is necessary. On the other hand, if the answer is no, then change is indicated. The cybernetic nature of SEES facilitates such renewal.

SEES: Informational Outputs

Solution Set Tables

The logic of the model, including the development of the logical relationships among the data elements, has been detailed in the preceding pages. Moreover, the specific input functions and actual output features are detailed in Appendix A. Therefore, the focus in this section is upon the informational outputs of the model.

As mentioned, once the data element values along with the options, ranges, and steps, have been specified, each requested percentage variation is calculated in combination with all other percentage variations for the enrollment and six personnel cost elements. The seventh personnel cost element, FTE part time faculty, is calculated last to balance cost

and income. Only those combinations which so balance are printed. These combinations, or more appropriately the solution set, are printed in table form.

The tables generated by the software follow the format shown in Tables 3.1, 3.2, and 3.3. These tables are reproductions of actual tables generated through use of SEES driven by actual cost and income data for the advanced and professional programs in Colleges A, B, and C, respectively.

For each element two values are given. The first value is the percentage change from the base. The second value is the resulting value after the percentage change has been applied to the base, i.e., the new value of enrollment of FTE staff positions.

In a complete output, the tables are sectioned by percentage changes in enrollment so that all solutions for each enrollment value are grouped together for analysis. Also, an input log, which prints back the input values matched against the element labels as read by the computer, is included in the complete output. An example of the input log is included in Appendix A.

In order to set the options, ranges, and steps and to insure comparability among the three colleges, a common scenario was assumed for each college. Specifically, it was assumed that the Division of Community Colleges' enrollment prediction for each college was a 7% decline. However, each college predicted no more than a 2% decline. In fact, each college believed, with an aggressive recruiting program, that enrollment could be increased 1%. In the case of the FTE full time faculty, 90% were tenured and another 6% unexpendable due to various internal

Table 3.1 Solution Set for College A Given a 1% Decline in Enrollment

MAY 14,1979

STAFF/ENROLLMENT EXPLORATION SYSTEM (SESES)
DISSERTATION EXAMPLE

SEMESTER CREDIT HOURS	FTE FT FACULTY	FTE PT FACULTY	FTE ADM FACULTY	FTE FACULTY SUP	FTE INDIRECT ADM	FTE INDIRECT OP	FTE INDIRECT SUP	FACULTY PROD RATIO
(-1.00%) 205076.50	(-4.00%) 268.62	(-48.71%) 15.94	(0.0 %) 9.30	(-2.00%) 12.15	(-2.00%) 18.71	(0.0 %) 31.44	(-2.00%) 201.48	(0.16%) 720.67
(-1.00%) 205076.50	(-4.00%) 268.62	(-49.40%) 15.71	(0.0 %) 9.30	(0.0 %) 12.40	(-2.00%) 18.71	(0.0 %) 31.44	(-2.00%) 201.48	(0.25%) 721.28

Table 3.2 Solution Set for College B Given a 1% Decline in Enrollment

MAY 14,1979

STAFF/ENROLLMENT EXPLORATION SYSTEM (SEES)
DISSERTATION EXAMPLE

SEMESTER CREDIT HOURS	FTE FT FACULTY	FTE PT FACULTY	FTE ADM FACULTY	FTE FACULTY SUP	FTE INDIRECT ADM	FTE INDIRECT OP	FTE INDIRECT SUP	FACULTY PROD RATIO
(-1.00X)	(-4.00X)	(17.36X)	(0.0 X)	(-2.00X)	(-2.00X)	(0.0 X)	(-2.00X)	(10.82X)
64824.21	37.32	26.28	3.56	19.43	5.84	12.59	55.13	1019.16
(-1.00X)	(-4.00X)	(-20.71X)	(0.0 X)	(-2.00X)	(-2.00X)	(0.0 X)	(0.0 X)	(11.90X)
64824.21	37.32	25.21	3.56	19.43	5.84	12.59	56.26	1036.80
(-1.00X)	(-4.00X)	(-10.72X)	(0.0 X)	(-2.00X)	(0.0 X)	(0.0 X)	(-2.00X)	(10.77X)
64824.21	37.32	25.05	3.56	19.43	5.96	12.59	55.13	1026.32
(-1.00X)	(-4.00X)	(-22.09X)	(0.0 X)	(-2.00X)	(0.0 X)	(0.0 X)	(0.0 X)	(12.68X)
64824.21	37.32	24.78	3.56	19.43	5.96	12.59	56.26	1044.01
(-1.00X)	(-4.00X)	(-10.50X)	(0.0 X)	(0.0 X)	(-2.00X)	(0.0 X)	(-2.00X)	(10.69X)
64824.21	37.32	25.89	3.56	19.03	5.84	12.59	55.13	1025.60
(-1.00X)	(-4.00X)	(-21.95X)	(0.0 X)	(0.0 X)	(-2.00X)	(0.0 X)	(0.0 X)	(12.60X)
64824.21	37.32	24.82	3.56	19.03	5.84	12.59	56.26	1036.26
(-1.00X)	(-4.00X)	(-19.94X)	(0.0 X)	(0.0 X)	(0.0 X)	(0.0 X)	(-2.00X)	(11.45X)
64824.21	37.32	25.46	3.56	19.03	5.96	12.59	55.13	1032.65
(-1.00X)	(-4.00X)	(-23.30X)	(0.0 X)	(0.0 X)	(0.0 X)	(0.0 X)	(0.0 X)	(13.38X)
64824.21	37.32	24.39	3.56	19.03	5.96	12.59	56.26	1050.56
(-1.00X)	(-4.00X)	(-21.57X)	(0.0 X)	(-2.00X)	(-2.00X)	(0.0 X)	(-2.00X)	(11.60X)
64824.21	37.70	24.94	3.56	19.43	5.84	12.59	55.13	1034.80
(-1.00X)	(-3.00X)	(-24.94X)	(0.0 X)	(-2.00X)	(-2.00X)	(0.0 X)	(0.0 X)	(13.62X)
64824.21	37.70	23.87	3.56	19.43	5.84	12.59	56.26	1052.28
(-1.00X)	(-3.00X)	(-22.93X)	(0.0 X)	(-2.00X)	(0.0 X)	(0.0 X)	(-2.00X)	(12.46X)
64824.21	37.70	24.51	3.56	19.43	5.96	12.59	55.13	1041.98
(-1.00X)	(-3.00X)	(-26.29X)	(0.0 X)	(-2.00X)	(0.0 X)	(0.0 X)	(0.0 X)	(14.43X)
64824.21	37.70	23.44	3.56	19.43	5.96	12.59	56.26	1060.21
(-1.00X)	(-3.00X)	(-22.79X)	(0.0 X)	(0.0 X)	(-2.00X)	(0.0 X)	(-2.00X)	(12.30X)
64824.21	37.70	24.65	3.56	19.03	5.84	12.59	55.13	1041.23
(-1.00X)	(-3.00X)	(-26.15X)	(0.0 X)	(0.0 X)	(-2.00X)	(0.0 X)	(0.0 X)	(14.34X)
64824.21	37.70	23.48	3.56	19.03	5.84	12.59	56.26	1059.44
(-1.00X)	(-3.00X)	(-24.15X)	(0.0 X)	(0.0 X)	(0.0 X)	(0.0 X)	(-2.00X)	(13.16X)
64824.21	37.70	24.12	3.56	19.03	5.96	12.59	55.13	1048.50
(-1.00X)	(-3.00X)	(-27.51X)	(0.0 X)	(0.0 X)	(0.0 X)	(0.0 X)	(0.0 X)	(15.06X)
64824.21	37.70	23.05	3.56	19.03	5.96	12.59	56.26	1066.97
(-1.00X)	(-2.00X)	(-25.70X)	(0.0 X)	(-2.00X)	(-2.00X)	(0.0 X)	(-2.00X)	(13.40X)
64824.21	38.09	23.60	3.56	19.43	5.84	12.59	55.13	1050.71
(-1.00X)	(-2.00X)	(-29.14X)	(0.0 X)	(-2.00X)	(-2.00X)	(0.0 X)	(0.0 X)	(15.40X)
64824.21	38.09	22.53	3.56	19.43	5.84	12.59	56.26	1069.26
(-1.00X)	(-2.00X)	(-27.14X)	(0.0 X)	(-2.00X)	(0.0 X)	(0.0 X)	(-2.00X)	(14.20X)
64824.21	38.09	23.17	3.56	19.43	5.96	12.59	55.13	1050.12
(-1.00X)	(-2.00X)	(-30.50X)	(0.0 X)	(-2.00X)	(0.0 X)	(0.0 X)	(0.0 X)	(16.23X)
64824.21	38.09	22.10	3.56	19.43	5.96	12.59	56.26	1076.93
(-1.00X)	(-2.00X)	(-26.99X)	(0.0 X)	(0.0 X)	(-2.00X)	(0.0 X)	(-2.00X)	(14.12X)
64824.21	38.09	23.22	3.56	19.03	5.84	12.59	55.13	1057.15
(-1.00X)	(-2.00X)	(-30.36X)	(0.0 X)	(0.0 X)	(-2.00X)	(0.0 X)	(0.0 X)	(16.14X)
64824.21	38.09	22.15	3.56	19.01	5.84	12.59	56.26	1076.13
(-1.00X)	(-2.00X)	(-28.35X)	(0.0 X)	(0.0 X)	(0.0 X)	(0.0 X)	(-2.00X)	(14.93X)
64824.21	38.09	22.78	3.56	19.03	5.96	12.59	55.13	1064.05
(-1.00X)	(-2.00X)	(-31.72X)	(0.0 X)	(0.0 X)	(0.0 X)	(0.0 X)	(0.0 X)	(16.90X)
64824.21	38.09	21.71	3.56	19.03	5.96	12.59	56.26	1083.90
(-1.00X)	(-1.00X)	(-29.90X)	(0.0 X)	(-2.00X)	(-2.00X)	(0.0 X)	(-2.00X)	(15.17X)
64824.21	38.48	22.27	3.56	19.43	5.84	12.59	55.13	1067.13

Table 3.3 Solution Set for College C Given a 1% Decline in Enrollment

MAY 14,1979 STATE ENROLLMENT EXTRAPOLATION SYSTEM (SEES)
DISSERTATION EXAMPLE

SEMESTER CREDIT HOURS	FTE FT FACULTY	FTE PT FACULTY	FTE ADM FACULTY	FTE FACULTY SUP	FTE INDIRECT ADM	FTE INDIRECT OP	FTE INDIRECT SUP	FACULTY PROFITABLE
(-1.00X) 26265.69	(-4.00X) 17.76	(-17.14X) 10.22	(0.0 X) 1.05	(-2.00X) 0.67	(-2.00X) 6.15	(0.0 X) 6.64	(-2.00X) 28.00	(-3.10X) 210.15
(-1.00X) 26265.69	(-4.00X) 17.76	(-22.60X) 9.51	(0.0 X) 1.05	(-2.00X) 0.67	(-2.00X) 6.15	(0.0 X) 6.64	(0.0 X) 28.65	(11.93X) 365.40
(-1.00X) 26265.69	(-4.00X) 17.76	(-20.64X) 9.78	(0.0 X) 1.05	(-2.00X) 0.67	(0.0 X) 6.29	(0.0 X) 6.64	(-2.00X) 28.00	(10.01X) 351.56
(-1.00X) 26265.69	(-4.00X) 17.76	(-26.19X) 9.10	(0.0 X) 1.05	(-2.00X) 0.67	(0.0 X) 6.29	(0.0 X) 6.64	(0.0 X) 28.65	(13.63X) 377.96
(-1.00X) 26265.69	(-4.00X) 17.76	(-17.34X) 10.19	(0.0 X) 1.05	(0.0 X) 0.68	(-2.00X) 6.15	(0.0 X) 6.64	(-2.00X) 28.00	(2.17X) 213.66
(-1.00X) 26265.69	(-4.00X) 17.76	(-22.09X) 9.51	(0.0 X) 1.05	(0.0 X) 0.68	(-2.00X) 6.15	(0.0 X) 6.64	(0.0 X) 28.65	(11.93X) 90.25
(-1.00X) 26265.69	(-4.00X) 17.76	(-20.04X) 9.76	(0.0 X) 1.05	(0.0 X) 0.68	(0.0 X) 6.29	(0.0 X) 6.64	(-2.00X) 28.01	(10.01X) 358.13
(-1.00X) 26265.69	(-4.00X) 17.76	(-26.19X) 9.08	(0.0 X) 1.05	(0.0 X) 0.68	(0.0 X) 6.29	(0.0 X) 6.64	(0.0 X) 28.65	(13.63X) 374.73
(-1.00X) 26265.69	(-3.00X) 17.94	(-21.62X) 9.66	(0.0 X) 1.05	(-2.00X) 0.67	(-2.00X) 6.15	(0.0 X) 6.64	(-2.00X) 28.00	(10.27X) 361.36
(-1.00X) 26265.69	(-3.00X) 17.94	(-27.10X) 8.90	(0.0 X) 1.05	(-2.00X) 0.67	(-2.00X) 6.15	(0.0 X) 6.64	(0.0 X) 28.65	(13.93X) 375.54
(-1.00X) 26265.69	(-3.00X) 17.94	(-25.17X) 9.23	(0.0 X) 1.05	(-2.00X) 0.67	(0.0 X) 6.28	(0.0 X) 6.64	(-2.00X) 28.00	(12.31X) 366.46
(-1.00X) 26265.69	(-3.00X) 17.94	(-30.68X) 8.55	(0.0 X) 1.05	(-2.00X) 0.67	(0.0 X) 6.28	(0.0 X) 6.64	(0.0 X) 28.65	(15.41X) 378.43
(-1.00X) 26265.69	(-3.00X) 17.94	(-21.62X) 9.66	(0.0 X) 1.05	(0.0 X) 0.68	(-2.00X) 6.15	(0.0 X) 6.64	(-2.00X) 28.00	(10.60X) 362.49
(-1.00X) 26265.69	(-3.00X) 17.94	(-27.37X) 8.96	(0.0 X) 1.05	(0.0 X) 0.68	(-2.00X) 6.15	(0.0 X) 6.64	(0.0 X) 28.65	(13.46X) 376.42
(-1.00X) 26265.69	(-3.00X) 17.94	(-25.17X) 9.24	(0.0 X) 1.05	(0.0 X) 0.68	(0.0 X) 6.28	(0.0 X) 6.64	(-2.00X) 28.00	(12.31X) 367.32
(-1.00X) 26265.69	(-3.00X) 17.94	(-30.68X) 8.52	(0.0 X) 1.05	(0.0 X) 0.68	(0.0 X) 6.28	(0.0 X) 6.64	(0.0 X) 28.65	(15.41X) 379.31
(-1.00X) 26265.69	(-2.00X) 18.13	(-26.41X) 9.11	(0.0 X) 1.05	(-2.00X) 0.67	(-2.00X) 6.15	(0.0 X) 6.64	(-2.00X) 28.00	(12.04X) 364.20
(-1.00X) 26265.69	(-2.00X) 18.13	(-31.66X) 8.43	(0.0 X) 1.05	(-2.00X) 0.67	(-2.00X) 6.15	(0.0 X) 6.64	(0.0 X) 28.65	(14.73X) 381.05
(-1.00X) 26265.69	(-2.00X) 18.13	(-29.41X) 8.68	(0.0 X) 1.05	(-2.00X) 0.67	(0.0 X) 6.28	(0.0 X) 6.64	(-2.00X) 28.00	(13.40X) 372.72
(-1.00X) 26265.69	(-2.00X) 18.13	(-35.41X) 7.99	(0.0 X) 1.05	(-2.00X) 0.67	(0.0 X) 6.28	(0.0 X) 6.64	(0.0 X) 28.65	(16.03X) 384.17
(-1.00X) 26265.69	(-2.00X) 18.11	(-26.30X) 9.09	(0.0 X) 1.05	(0.0 X) 0.68	(-2.00X) 6.15	(0.0 X) 6.64	(-2.00X) 28.00	(12.19X) 365.05
(-1.00X) 26265.69	(-2.00X) 18.13	(31.05X) 8.40	(0.0 X) 1.05	(0.0 X) 0.68	(-2.00X) 6.15	(0.0 X) 6.64	(0.0 X) 28.65	(15.04X) 382.53
(-1.00X) 26265.69	(-2.00X) 18.13	(29.00X) 8.66	(0.0 X) 1.05	(0.0 X) 0.68	(0.0 X) 6.28	(0.0 X) 6.64	(-2.00X) 28.00	(13.92X) 373.69
(-1.00X) 26265.69	(-2.00X) 18.13	(-35.35X) 7.97	(0.0 X) 1.05	(0.0 X) 0.68	(0.0 X) 6.28	(0.0 X) 6.64	(0.0 X) 28.65	(16.24X) 386.14
(-1.00X) 26265.69	(-1.00X) 18.31	(30.59X) 8.56	(0.0 X) 1.05	(-2.00X) 0.67	(-2.00X) 6.15	(0.0 X) 6.64	(-2.00X) 28.00	(13.51X) 377.19

situations. Thus, the maximum percentage of faculty which could be retrenched or reduced in force (RIFed) would be 4% and there was no justification for any increase. Since an enrollment decline would not change the administrative workloads of the faculty (a department chairperson was always needed), no change was specified for this element. However, with fewer students an adjustment could be made in faculty support. This adjustment could only be a reduction of one position which was a 2% change or it could not occur at all. Another problem surfaced with regard to indirect costs. In this case, headcount had been increasing at a rate twice that of FTE students. In fact, headcount was projected to increase slightly, even with a decline in FTE students. Accordingly, the indirect costs could be expected to remain relatively fixed; it would not be feasible to reduce FTE indirect other professional staffs (primarily student services) although some reduction was possible for the FTE indirect administration and the FTE indirect support staffs.

In addition to these circumstances, the executive council, along with advice from the faculty senate, decided, for quality reasons, that FTE part time faculty should not be either increased or decreased by more than 50% and that the faculty productivity ratio should not be increased or decreased by more than 20%.

All of these factors were to be accounted for within a budget that was specified to balance to zero including a 10% tuition fee waiver package.

Solution sets to this scenario, given a 1% decline in enrollment are presented in Tables 3.1, 3.2, and 3.3 for each college, respectively. For comparability, only the first page of solution sets for a 1% decline was printed.

The most striking observation concerning the three tables is that College A has only two solutions given a 1% decline while Colleges B and C have 25 (actually each has 38 solutions; 13 additional solutions were printed on another page of the computer output). The point is that what is not printed is just as important, in some cases, as what is printed.

In addition, it is of interest to note that the alternatives for both College B and College C are similar. However, College C's range of percentage change for FTE part time faculty is slightly broader, -17.14% to -35.35%, as compared to College B's, -17.36% to -31.72%.

Finally, two general observations concerning the complete output (not reproduced here) are of interest. First, in all solution sets for all colleges, the faculty productivity ratio increases. Second, none of the colleges have any solutions, given the input parameters, for enrollment declines of more than 2%. In fact, College A's first solution was in the 1% decline category.

Graphs

Although not part of the SEES software, various values of enrollment, staff, and productivity may be graphed to demonstrate cost-income relationships. The most important of these relationships, for flexibility purposes, is the percent change of FTE part time faculty needed to balance the budget as a function of enrollment fluctuation without changing any other personnel cost element. In other words, just how much flexibility is inherent in potential changes in part time faculty? This relationship for each of the three colleges is presented in Figures 3.2, 3.3, and 3.4.

In order to demonstrate this flexibility relationship, the enrollment value was set to range from -25% to 25% in steps of 5. All other

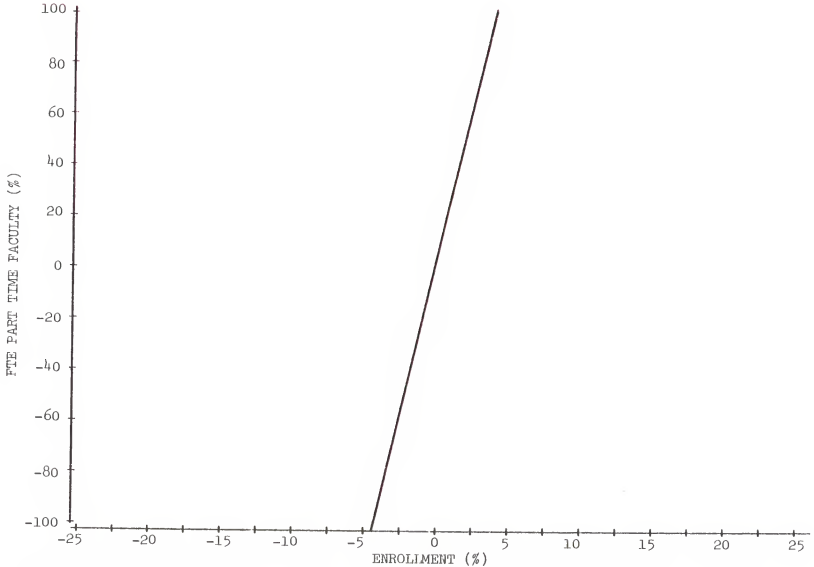

Figure 3.2 Percentage Change in FTE Part Time Faculty to Balance the Budget as a Function of Enrollment Change in College A

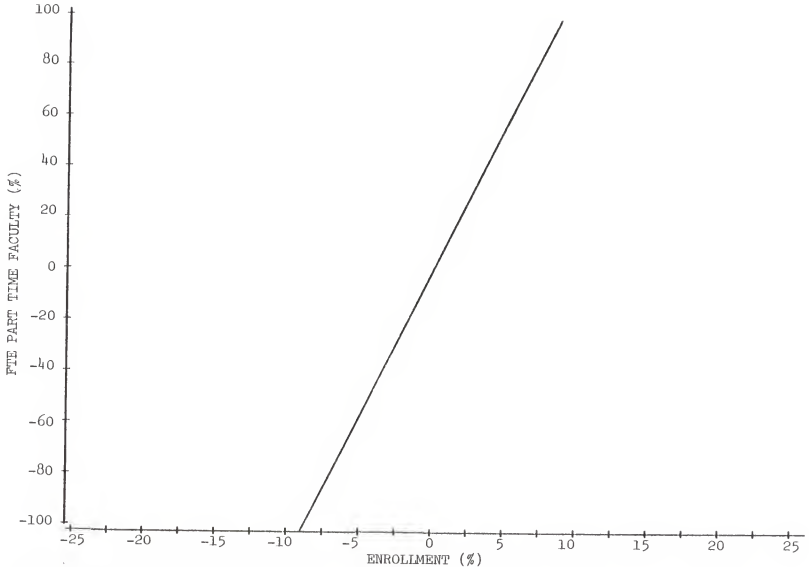

Figure 3.3 Percentage Change in FTE Part Time Faculty to Balance the Budget as a Function of Enrollment Change in College B

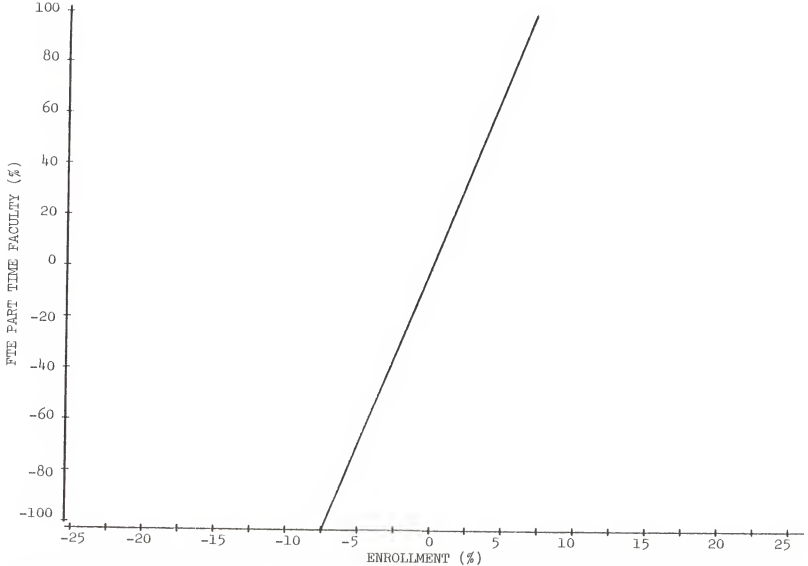

Figure 3.4 Percentage Change in FTE Part Time Faculty to Balance the Budget as a Function of Enrollment Change in College C

input parameters were held constant as in the previous examples (Tables 3.1, 3.2, and 3.3). From the subsequent output, the percentage values of the FTE part time faculty in the solution set containing no change in the other personnel elements for each enrollment change were identified. These percentage values were plotted on the vertical axis against the enrollment values which were plotted on the horizontal axis. The figures were generated using the Statistical Package for the Social Sciences (SPSS), subprogram Scattergram.

The relationship is clearly demonstrated by connecting the plotted points with a diagonal line. It is possible to determine how much of an enrollment change can be handled by percentage changes in FTE part time faculty. For example, the percentage reduction in FTE part time faculty necessary to balance the budget in any percentage enrollment decline can be determined. The maximum percentage enrollment decline which can be handled entirely through reductions in part time faculty can also be determined. For instance, College A can handle a 4.5% decline by cutting 100% of the FTE part time faculty, while College B can handle a 9.5% decline and College C can handle a 7.5% decline.

Finally, if an enrollment increase were expected, one can determine how much part time faculty must be added to increase flexibility while holding FTE full time faculty constant.

In short, there are numerous applications for the informational outputs of SEES. Many different relationships may be explored under virtually infinite cost and income conditions.

CHAPTER IV

EVALUATION

Introduction

After the model was developed, it was evaluated by each of the colleges participating in the study. Accordingly, Chapter IV covers the results of this evaluation. The chapter is organized according to the colleges' responses to the specific criteria associated with the model's performance, utility, time, and cost. The chapter is concluded with a discussion of the responses to the evaluation.

Originally, two evaluation instruments (Appendix C) were sent to each college. One was to be completed by the director of institutional research while the other was to be completed by the appropriate budget officer. However, in each case the two representatives evaluated the model in conference; hence, each college returned one instrument. Thus, the responses are discussed as college responses rather than as individual responses.

College Responses

Performance

Does the model effectively answer questions related to cost-income flexibility? The responses to this question were mixed which may have been a function of different conceptions of the definition of cost-income

flexibility. College A gave a simple "yes" answer. College B responded that the "model provides a great deal of insight into a variety of possible alternatives"; however, "the model does not necessarily answer questions related to cost-income flexibility." In this case, the model was judged to answer cost-income questions according to the definition offered in Chapter I. College C answered, "partly--staffing only."

Does it meet institutional needs to model cost-income flexibility? College A again gave a simple "yes" answer. College B also gave a "yes" answer and explained:

> The model is designed to examine a wide variety of programmatic situations. Studies can be made at any level of aggregation chosen. This allows institutions to pinpoint problems and examine alternative solutions.

College C again responded, "partly--staffing only."

How well does it relate institutional policy to cost-income flexibility? Both College A and College C qualified the kinds of policies which were related to cost-income flexibility. Specifically, these two colleges pointed to policies which dealt with staffing and productivity considerations in light of the cost-based financing system used in Florida. College B indicated that such cost-income studies had been conducted in the past "to provide input into program evaluation. Therefore, the model supports established policy and extends the scope of the previous studies."

Utility

How useful is the model? This was one of the most salient questions asked. Both College A and College B saw the model as being highly useful. Specifically, College B responded:

> The model seems to have potential in several areas of analysis. The model has value in determining the causes of past problems, thus, providing guidelines for establishing preventive measures. The model could be run on proposed budgets to allow managers to examine the implications of their budgets under possible perturbations which could occur during the year and give some possible solutions to problems these perturbations might create. The model can also be used to monitor programs throughout a budget period. The monitoring by the model also points up possible alternative methods of operation.

College C stated that the model's use "is somewhat limited." This perceived limitation was due to the fact that it "seems mainly (if not totally) concerned with instructional personnel." College C added, "However, it is a step in the right direction; we need models like this related to other problems."

Could it be used routinely? Both College A and College C responded with a simple "yes" answer. College B also gave an affirmative answer and added some suggestions:

> The principle work required to run the model comes in the initial data collection. Base line data on indirect cost can be developed in such a way as to allow easy specification to any run. If a methodology is developed for the faculty elements which will standardize sources of data, the model can be run routinely at any level of aggregation. By the standardizing of sources, the compatibility of information between runs is greatly improved.

How well would it adapt to institutional change? College A responded that the model would readily adapt to institutional change "given the ease of changing data input." College B was also affirmative but pointed out that the major problem with institutional change "would be the establishment of new base data." College B further pointed out that the model, if used as a monitoring device, "could, in fact, assist in pointing out the need for change." College C, while responding "reasonably well", pointed out that "it would be limited to established programs for which historical data are available."

Time

How much time is necessary for installation? The responses to this question ranged from College A's "very little" to College B's "about fifteen minutes" and finally to College C's "don't know."

How much time is required for collecting the data base necessary to operate the system? At the time of the evaluation, College A had not yet compiled the data to drive the model. However, it was "anticipated that no more than several hours will be needed to compile the data from source documents." College B covered several different applications:

> (We) can only give definite time data on runs made on cost analysis data. One half day is more than enough for initial loading. One to two hours would cover most other situations. (We) do not see budget runs taking any longer. Monitoring runs could take longer because data might have to come from a larger number of sources.

College C again responded "don't know."

Cost

If you had sufficient funds and were not able to receive installation . . . , how much would you be willing to pay for SEES and its installation on your computer? This question received the least concise remarks. College A responded that the evaluators "have no way to estimate the amount because the decision would reside with senior management." College C again responded "don't know." The sentiment was perhaps best expressed by College B:

> (We) do not feel qualified to answer this question. Our institution does not buy models. We get models through IRC or develop our own. We usually cooperate with IRC on model development and are assured of their adaptability to our needs.

Discussion of the Responses

It is clear, in general, that SEES was evaluated "high" relative to performance, utility, and time. The question of cost was indeterminable.

With regard to performance, all institutions responded affirmatively to all three questions. Two limitations were noted however. First, there seemed to be a difference of opinion as to the definition of cost-income flexibility. However, as cost-income flexibility has been defined as the administrative ability to allocate resources through alternative policy measures with an increase in alternatives equating to an increase in flexibility, it was clear that the model, from the colleges' point of view, performed this function. The second limitation was that only policies related to staff, productivity, and funding were considered. This too was the intended scope of the model. In sum, the colleges responded that the model did indeed meet institutional needs.

The question of utility was probably the most salient of all the questions because if the model were not viewed as being useful it would not be used and, therefore, all of the other criteria would be meaningless. The model was judged to be highly useful by two of the colleges; the third college was less enthusiastic. This lack of enthusiasm may have been due to some misunderstanding of the model in that the specific concerns indicated that this college believed the model to be designed only (or solely) for instructional personnel. This was not the case.

Moreover, the model was evaluated "high" in the criteria associated with ability to be used routinely and ability to adapt to institutional change.

The model was also rated "high" on the criterion associated with time. Of particular importance were the responses concerning the time to collect the data base. It was clear that the colleges would not increase their data collection activities and thus, if the model were designed to require new data collection activities, it would severely hamper the utility of the model.

The cost criterion yielded "don't know" kinds of responses. However, it may be assumed, given the low cost to the membership coupled with the high ratings on the other criteria, that the information was indeed worth the cost. In fact, consortia approaches may be the least expensive way to develop such planning models. It was doubtful that any single institution would have had the resources (time, expertise, and money) to develop the model individually.

In conclusion, SEES was rated "high" according to virtually all of the evaluative criteria. Given that a model was synthesized, that a methodological outline for the synthesis of planning models in general was developed, and that the model was positively evaluated, it was apparent that the objectives of the study had been met.

CHAPTER V

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS FOR FURTHER RESEARCH

Introduction

Since research frequently requires succinct summarization and since it often poses as many questions as are answered, Chapter V serves to relate the study to future research needs. Accordingly, a summary of the study along with implications leading to a discussion of recommendations for further research is presented in Chapter V.

Summary

In this study constructs associated with simulation, modeling, MIS, cost analyses, and evaluation were synthesized into a planning model for modeling cost-income flexibility in Florida community colleges. As a corollary, a methodological outline for the synthesis of planning models in general was developed.

More specifically, Staff/Enrollment Exploration System (SEES) was developed, validated, and evaluated through application of systems analysis. The systems analysis was conducted according to steps recommended by Banghart (1969, pp. 29-41). The steps were supplemented through the addition of a step to establish validity and to provide evaluation (refer to pp. 5-7 of the study).

After the objectives of the study were set and an extensive review of general systems operations was completed, three Florida community colleges were selected for a review of specific systems operations. Data were collected from several sources and were analyzed through use of an existing simulation model, Budget Simulator. This led to the isolation of the specific constructs needed to solve the problem. Once these constructs were identified, operations were specified, data elements for the model were determined, and the logical and mathematical relationships among the data elements were developed. These relationships were programmed for computer assistance. This led to the prototype model.

The final model was validated by submitting the prototype model to a three-step process in which panels of experts reviewed the model for face and content validity.

Once the model was completed, data from each of the participating institutions were introduced to the model to produce tables of staff and enrollment solution sets to balance the institutions' budgets. In addition, graphs of the relationship between full-time equivalent (FTE) part time faculty change to balance the budget as a function of enrollment were produced. This, plus installation of the software in each of the three colleges, provided the basis for evaluation of the model according to criteria associated with performance, utility, time, and cost (refer to Appendix C).

Implications

The overriding implication of the study was that planning models and methodologies could be developed through application of general

systems theory and systems analysis. In other words, theory could be translated into practice. And, a direct and applied implication was that, as a model was developed which was evaluated satisfactorily, the management and planning efforts of Florida community colleges were enhanced.

Recommendations for Further Research

In that the problem of the study was resolved through application of general systems theory and systems analysis, three general research recommendations are noted:

1. More research should be directed toward applications of systems concepts, constructs, and operations.
2. Inter-disciplinary approaches should be synthesized to take advantage of knowledge developed outside of educational disciplines.
3. The logic of systems should be studied with attention to the heuristic properties of general systems theory.

Following these general recommendations, more specific recommendations are offered:

1. Study should be undertaken concerning the implications of general systems concepts, constructs, and operations for educational systems. For example, some doubt existed regarding the relevance of entropy for open systems (Melcher, 1975, pp. 3-31).
2. Other planning models should be developed by using Staff/Enrollment Exploration System and the methodological outline of this study.
3. Study should be directed toward research applications of Staff/Enrollment Exploration System. For example, various relationships between cost and income data could be studied.
4. Inter-disciplinary research paradigms should be encouraged in the preparation of educational administrators.

5. Evaluations of experimental research paradigms vis-a-vis systems analysis paradigms should be supported. These evaluations should focus upon educational systems, with particular attention given the managerial subsystems. For example, questions concerning the meanings of validity and reliability relative to both paradigms could be researched in order to strengthen both paradigms.

As a final recommendation and as a conclusion, it was noted that practitioners experienced a wide range of reactions to the use of computer-based planning models. In some cases, this impeded the full implementation of the model. Accordingly, not only must students be trained in general systems theory and applications, but also practitioners must be provided in-service opportunities to update their skills. This final recommendation and its implications may be the most important and challenging of all of the foregoing recommendations. After all, if no one uses the information in decision-making, the information, no matter how potentially useful it is, is indeed useless.

APPENDIX A

DOCUMENTATION

STAFF/ENROLLMENT EXPLORATION SYSTEM (SEES): MODELING COST-INCOME FLEXIBILITY FOR FLORIDA COMMUNITY COLLEGES

By

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April, 1979

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Preface

We have come to expect our problems to be solved and in most instances our faith has been rewarded. However, as complexity has increased and resources become more limited, the solutions have been more difficult to find. A view of the next few years gives us no pause to rest. We may move from crisis to crisis in an ever increasing speed--a movement toward entropy itself. To solve our problems during the 1980's we must continue to seek dynamic and creative approaches to planning and to the research that must back it up. SEES is, I believe, an example of such an approach. The central utility of SEES lies in the fact that decision makers will be able to simulate alternative solutions without suffering the consequences when it is too late. Information regarding the financial impact of various decisions regarding changes in enrollment vis a vis alternative staffing and faculty productivity plans will be readily available. Since SEES is designed to yield only solution sets which balance the budget, plans which would imbalance the budget are identified prior to an imbalance truly occurring.

But SEES is more than a highly informative planning model. SEES is an example of the growing use of operations research and systems analysis to provide tools to enhance decision making in periods of increasing uncertainty. As such, SEES bridges theory and practice in an exemplary way; its heuristic qualities hopefully will stimulate the creation of yet other models.

Institutional research and planning are necessarily evolving to meet the needs of the future. The IRC motto, "Cooperation for Progress Through Research," continues to be most relevant.

James L. Wattenbarger
Director, Institute of
Higher Education

STAFF/ENROLLMENT EXPLORATION SYSTEM (SEES)

Introduction

Staff/Enrollment Exploration System (SEES) is a computer based simulation model which provides the user with a way of modeling cost-income flexibility associated with various staffing alternatives and resultant faculty productivity ratios under conditions of changes in enrollments and in funding allocations per fundable unit. Specifically, the user can determine all possible staffing alternatives which balance an institution's budget given enrollment and funding expectations. For example, assume that, using two different methods of projection, enrollment is predicted to decline 7% and to increase 1% respectively. SEES can then be set to explore the impact of these possible enrollment fluctuations (along with funding expectations) upon staffing plans. The user specifies the range and steps for exploration, e.g., range from -7% to +1% in steps of one. In the same way, bearing in mind institutional policies and the behavior of the cost elements, ranges may be set for faculty productivity ratios and for each of six personnel cost elements with the seventh personnel cost element, full time equivalent (FTE) part time faculty, allowed to "float" i.e., calculated last, in order to provide a precise determination of the flexibility of each particular solution set. Specification of ranges allows users to add judgemental and qualitative decisions related to both institutional policies, e.g., tenure policies, and to the actual behavior of a personnel cost element, e.g., costs which are variable, semi-variable, or fixed in relation to enrollment fluctuations.

Model Development

SEES is built upon an equation that mathematically expresses all possible cost and income elements relative to Florida's community colleges. Face and content validity was established through review of the model, and particularly the equation, by a panel of five expert practitioners in the fields of management information systems (MIS), cost analysis, budgeting, and internal auditing. More detailed information is available upon request.

Data Requirements

SEES is constructed so that data available from the yearly Cost Analysis (CA-2) can be used to provide most of the cost elements. However, any element values can be specified for exploration purposes. The income elements are either known or can be estimated. The following is a list of the required elements and suggested sources of data:

Cost Elements

Full time equivalent (FTE) full time faculty. SEES requires an actual or an estimated full time/part time FTE ratio. This is available, historically, in the Cost Analysis working papers. It may also be a matter of institutional record. Using this ratio, the instructional expenditures as reported in the CA-2 can be broken down to supply this element and the next two. Specifically:

1. Apply ratio to determine FTE's for both full time and part time.

2. Multiply the part time FTE's by the average part time salary (discussed below). This yields total part time expenditures.

3. Subtract total part time expenditures from total expenditures to yield total full time expenditures.

Average salary and benefits FTE full time faculty. Divide result of Step 3 above by the FTE full time faculty as determined in Step 1.

FTE part time faculty. Determined in Step 1 above.

Average salary and benefits FTE part time faculty. This is the salary (and benefits if any) needed to cover credit hour production of an FTE full time faculty. For example, in the Cost Analysis, one FTE faculty is defined, production-wise, as teaching 42 credit hours. To handle 42 credit hours with part time faculty a total of 14 courses must be taught (14 courses x 3 credit hours = 42). Assuming an average remuneration per course of $600, the total expenditure to cover an FTE full time faculty load is $8,400 ($600 x 14 courses = $8,400).

All of the following data elements are available from the CA-2. One must note that a ratio method is used to allocate all of the indirect costs to an instructional program. That is, the ratio of production in the program to production college-wide (prog. prod./coll. prod.) is applied to all indirect costs. For example if the Advanced and Professional program produced 1000 credit hours and the total college production was 4,000 the ratio would be 1000/4000 = .25. Thus 25% of the indirect costs would be allocated to the Advanced and Professional program.

FTE administrative faculty.

Average salary-benefits FTE administrative faculty.

FTE faculty support.

Average salary-benefits FTE faculty support.

Faculty supplies and services.

Faculty capital outlay. This covers equipment expenditures.

Faculty equipment replacement. This element is to be used only if some funds will be set aside for the future.

FTE indirect administration.

Average salary-benefits indirect administration.
FTE indirect other professional.
Average salary-benefits FTE indirect other professional.
FTE indirect support.
Average salary-benefits indirect support.
Indirect supplies and services.
Indirect capital outlay. This covers equipment expenditures.
Indirect equipment replacement. This element is to be used only if some funds will be set aside for the future.
Other. The final cost element covers special cases not covered in the historical Cost Analysis but which may be expected in the future.

Income Elements

Student semester credit hours. SEES accepts any value. Several projections may be compared, e.g., state office and institutional.
Discipline weight. Future weights are determined by the Cost Analysis. These are available from the Division of Community Colleges or can be estimated. If SEES is applied to an entire program level, e.g., Advanced and Professional, an average weight must be computed.
Unitary FTE. Depending on the time of year this is either known or must be estimated based on available information.
Tuition per credit hour. For exploration purposes, this can be any value. An historical average can be used to account for instate-outstate differentials.
Federal funds. Those funds which are expected from known (and/or possible) grant sources which can be applied to the program being modeled.
Other. Auxillary incomes, special fees, and gifts are covered. Most business offices have at least estimated figures.

Options

Several user options have been built into SEES to insure greater flexibility:

Balance input. For all explorations, SEES holds constant the balance resulting from the solution of the equation. The user may specify a desired balance or may request that the balance be calculated from the input elements.
Student credit hour fee waiver factor. Allows specifications of a percentage reduction in projected credit hour production to account for fees that are waived.
Solution set limitation. Since both the FTE part time faculty and the faculty productivity ratio (SCH/FTE ft faculty + FTE pt faculty) are calculated independently of forced constraints, some illogical solutions might appear, e.g., reduce part time faculty by 600%, or increase productivity ratios by 100%. By requesting this limitation option and specifying logical limits, all solutions exceeding these limits are not

printed. It should be noted however, that, particularly in the first explorations, all solution sets may be of interest. For example, although one may wish not to reduce part timers by more than 50%, a solution set which includes a 51% reduction may be the most feasible, given other staffing alternatives. If the limit option had been specified, this solution set would not have been printed.

Specification of Ranges and Steps

As mentioned, the model accounts for institutional policies and individual element behaviors through specification of ranges of variance. An example is illustrative. Assume that 90% of the faculty are tenured. Additionally, of those that are not tenured only 5% are expendable given an enrollment decline in specialized areas. Moreover, given an increase in headcount (with a slight drop in FTE) it is imperative to increase personnel in student services. This kind of discussion typically takes place in academic or executive councils. And, these kinds of situations can be handled by SEES through applying ranges to the elements; FTE full time faculty can vary from -5% to 0% and other professionals may vary from 0% to +4%. Thus, educational planners can transform judgemental and qualitative decisions pondered in the top councils into quantitative constraints which, through SEES, can be used to demonstrate the flexibility associated with all ranges of impending decisions.

Specification of ranges and steps also controls the volume of the output. Although theoretically there is no limit to the ranges and steps specified, users should be aware that the output can grow rather large. One can determine the number of solution sets by multiplying the number of steps within each range by one another. Using the example above, the ranges and steps specified yield 5852 solution sets:

				Total Steps
SCH	-7	+1	Steps 1	9
FTE FT Faculty	-5	0	Steps 1	6
FTE Adm. Faculty	-2	0	Steps 2	2
FTE Faculty Support	-2	0	Steps 2	2
FTE Indirect Adm.	0	+4	Steps 2	3
FTE Indirect OP	0	+4	Steps 2	3
FTE Indirect Support	0	+4	Steps 2	3

Yields: 9x6x2x2x3x3x3 = 5852 solution sets

Input: Program Deck Set-Up

All of the following cards, in the following order, are required to drive SEES:

Systems Card(s)

These are the card(s) necessary to enter the job into a particular computer system.

Execution of SEES Card

This card calls SEES from the library of source programs.

Title Card

This card enables the user to title a particular exploration. The title can be punched using columns 1-80.

Date Card

This card allows the user to date the particular exploration. The date can be punched in columns 1-20.

Cost-Income Element Value Cards

One card is punched for each of the 27 cost and income elements. Each value is punched in columns 1-10 with a decimal occurring in any position. For non-decimal values, the user may either right adjust or may begin in column 1 being sure to add a decimal at the end of the expression. The user must begin with the cost elements:

Card	Column(s)	Element
1	1-10	FTE full time faculty
2	1-10	Av. salary-benefits FTE full time faculty
.		
.		
27	1-10	Other

Example

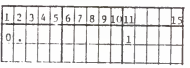
Cols.	1	2	3	4	5	6	7	8	9	10
	.3	8	.	8	7					
	.2	8	9	0	8	.	5	3		
	.0	.								

Option Card(s)

Four cards are prepared to specify the following options:

Card	Column(s)	Option
1	1-11	Balance input

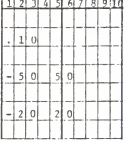
Example



If a balance is specified, the user specifies the balance in columns 1-10 using the same rules as used with the cost-income elements. Additionally, "1" must be punched in column 11. If this card is blank or "0" is punched in column 11, the balance will be calculated from the input elements.

Card	Column(s)	Option
2	1-10	Fee waiver factor
3	1-3 Minimum 4-6 Maximum	FTE part time faculty limits
4	1-3 Minimum 4-6 Maximum	Faculty productivity limits

Example



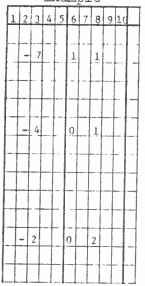
A blank card may be substituted for all of the options cards if the user does not desire the option(s).

Range and Step Specification Cards

These cards specify the ranges and steps of exploration for the enrollment and six personnel cost elements. A single card is punched for each of the seven elements. Each requires specification of a minimum and maximum value to set the range along with the required steps:

Card	Column(s)	Element
1	1-3 Minimum 4-6 Maximum 7-8 Steps	Student semester credit hours
2	1-3 Minimum 4-6 Maximum 7-8 Steps	FTE full time faculty
.		
.		
.		
7	1-3 Minimum 4-6 Maximum 7-8 Steps	FTE indirect support

Example



Example Input

Figure 1 is a reproduction of an actual input deck set-up taken from a coding sheet. Each line represents a card with the characters beginning in Column 1.

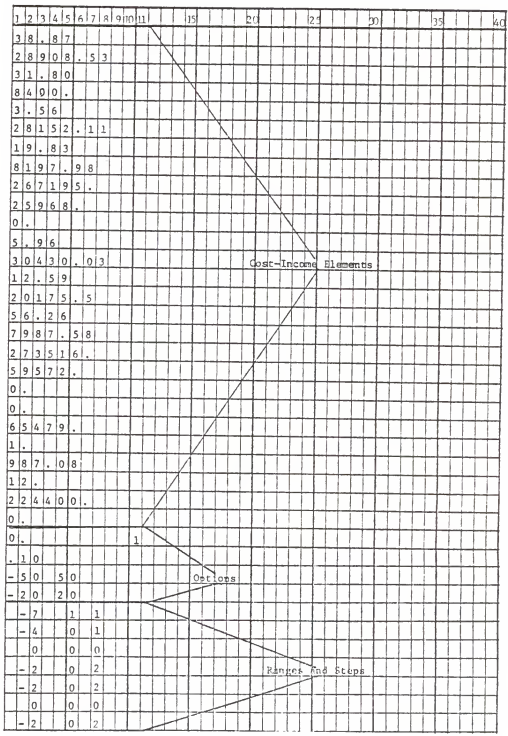


Figure 1. Input Deck Set-Up

Output: Input Log and Tables of Solution Sets

Figure 2 is a reproduction of an input log provided in every output of SEES. This log may be used to verify input entries and as a worksheet to change input values. Users should always check the input log for input errors.

```
APRIL 4, 1979                    STAFF/ENROLLMENT EXPLORATION SYSTEM (SEES)
                                          DOCUMENTATION EXAMPLE

FTE FT FACULTY                          38.07
AV SALARY-BENEFITS - FTE FT FACULTY  28908.53
FTE PT FACULTY                          31.00
AV SALARY-BENEFITS - FTE PT FACULTY   8400.00
FTE ADMINISTRATION FACULTY                3.50
AV SALARY-BENEFITS - FTE ADMIN FAC   28152.11
FTE FACULTY SUPPORT                      19.83
AV SALARY-BENEFITS - FTE FAC SUPT     8197.98
FACULTY SUPPLIES & SERVICES         267175.00
FACULTY CAPITAL OUTLAY               25968.00
FACULTY EQUIPMENT REPLACEMENT            0.0
FTE INDIRECT ADMINISTRATION              5.26
AV SALARY-BENEFITS INDIRECT ADMIN    30430.00
FTE INDIRECT OTHER PROFESSIONAL          12.53
AV SALARY-BENEFITS IND OTHER PROF    20175.50
FTE INDIRECT SUPPORT                     56.26
AV SALARY-BENEFITS INDIRECT SUPPORT   7987.51
INDIRECT SUPPLIES & SERVICES        273516.00
INDIRECT CAPITAL OUTLAY              59872.00
INDIRECT EQUIPMENT REPLACEMENT           0.0
OTHER                                    0.0

SEMESTER CREDIT HOURS                65479.00
WEIGHT                                   1.00
UNITARY FTE                            987.08
TUITION                                 12.00
FEDERAL FUND                        224400.00
OTHER                                    0.0

SPECIFIC BALANCE                         0.0
FACTOR                                   0.10
FTE PT FACULTY                  LIMITS FROM  -50% TO  50%
FACULTY PRODUCTIVITY RATIO      LIMITS FROM  -20% TO  20%

SEMESTER CREDIT HOURS           RANGE FROM   -7% TO   1% IN STEPS OF  1
FTE FT FACULTY                  RANGE FROM   -4% TO   0% IN STEPS OF  1
FTE ADMINISTRATION FACULTY      RANGE FROM    0% TO   0% IN STEPS OF  0
FTE FACULTY SUPPORT             RANGE FROM   -2% TO   0% IN STEPS OF  2
FTE INDIRECT ADMINISTRATION     RANGE FROM   -2% TO   0% IN STEPS OF  2
FTE INDIRECT OTHER PROFESSIONAL RANGE FROM    0% TO   0% IN STEPS OF  0
FTE INDIRECT SUPPORT            RANGE FROM   -2% TO   0% IN STEPS OF  2

CALCULATED BALANCE                    -6.44
CALCULATED FACULTY PROD. RATIO       926.55
```

Figure 2. Input Log

The following table is a reproduction of an actual table produced by SEES using the input listed above in Figure 2. Each solution set is calculated starting with the minimum (-) values of all the elements and concluding with the maximum (+). Further, the solutions are grouped by each step in the enrollment fluctuation range. In this example, limits for FTE part time faculty were set to range from -50% to 50% and faculty productivity ratios were set to range from -20% to 20%. The balance was specified as zero with a 10% fee waiver reduction.

(1) CREDIT CHARGES	(2) FIT	(3) FIT	(4) FIT	(5)	(6)	(7)	(8)	(9)
(-1.00)X1 64424.21	(-4.00)X1 37.32	(-17.16)X1 26.20	(0.0)X1 3.56	(-2.00)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(-2.00)X1 56.13	1040.36
(-1.00)X1 64424.21	(-4.00)X1 37.32	(-20.73)X1 24.23	(0.0)X1 3.56	(-2.00)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1036.90
(-1.00)X1 64424.21	(-4.00)X1 37.32	(-18.77)X1 25.05	(0.0)X1 3.56	(-2.00)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(-2.00)X1 56.13	1038.76
(-1.00)X1 64424.21	(-4.00)X1 37.32	(-22.09)X1 24.70	(0.0)X1 3.56	(-2.00)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1035.81
(-1.00)X1 64424.21	(-4.00)X1 37.32	(-18.53)X1 25.89	(0.0)X1 3.56	(0.0)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(-2.00)X1 56.13	1039.40
(-1.00)X1 64424.21	(-4.00)X1 37.32	(-21.05)X1 24.62	(0.0)X1 3.56	(0.0)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1043.26
(-1.00)X1 64424.21	(-4.00)X1 37.32	(-19.09)X1 25.46	(0.0)X1 3.56	(0.0)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(-2.00)X1 56.13	1041.65
(-1.00)X1 64424.21	(-4.00)X1 37.32	(-23.30)X1 24.39	(0.0)X1 3.56	(0.0)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1038.56
(-1.00)X1 64424.21	(-3.00)X1 37.70	(-21.27)X1 24.24	(0.0)X1 3.56	(-2.00)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(-2.00)X1 56.13	1039.80
(-1.00)X1 64424.21	(-3.00)X1 37.70	(-24.79)X1 23.87	(0.0)X1 3.56	(-2.00)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1036.78
(-1.00)X1 64424.21	(-3.00)X1 37.70	(-22.19)X1 24.51	(0.0)X1 3.56	(-2.00)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(-2.00)X1 56.13	1041.90
(-1.00)X1 64424.21	(-3.00)X1 37.70	(-26.29)X1 23.44	(0.0)X1 3.56	(-2.00)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1035.81
(-1.00)X1 64424.21	(-3.00)X1 37.70	(-22.79)X1 24.05	(0.0)X1 3.56	(0.0)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(-2.00)X1 56.13	1041.23
(-1.00)X1 64424.21	(-3.00)X1 37.70	(-26.15)X1 23.40	(0.0)X1 3.56	(0.0)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1035.94
(-1.00)X1 64424.21	(-3.00)X1 37.70	(-24.15)X1 24.12	(0.0)X1 3.56	(0.0)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(-2.00)X1 56.13	1040.50
(-1.00)X1 64424.21	(-3.00)X1 37.70	(-27.25)X1 23.05	(0.0)X1 3.56	(0.0)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1034.26
(-1.00)X1 64424.21	(-2.00)X1 38.09	(-25.70)X1 23.63	(0.0)X1 3.56	(-2.00)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(-2.00)X1 55.13	1035.71
(-1.00)X1 64424.21	(-2.00)X1 38.09	(-29.14)X1 23.23	(0.0)X1 3.56	(-2.00)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1031.76
(-1.00)X1 64424.21	(-2.00)X1 38.09	(-27.14)X1 23.67	(0.0)X1 3.56	(-2.00)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(-2.00)X1 55.13	1033.67
(-1.00)X1 64424.21	(-2.00)X1 38.09	(-30.00)X1 22.10	(0.0)X1 3.56	(-2.00)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1030.23
(-1.00)X1 64424.21	(-2.00)X1 38.09	(-26.09)X1 23.03	(0.0)X1 3.56	(0.0)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(-2.00)X1 55.13	1034.23
(-1.00)X1 64424.21	(-2.00)X1 38.09	(-30.31)X1 22.15	(0.0)X1 3.56	(0.0)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1029.93
(-1.00)X1 64424.21	(-2.00)X1 38.09	(-28.35)X1 22.78	(0.0)X1 3.56	(0.0)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(-2.00)X1 55.13	1032.48
(-1.00)X1 64424.21	(-2.00)X1 38.09	(-31.75)X1 21.71	(0.0)X1 3.56	(0.0)X1 19.43	(0.0)X1 5.84	(0.0)X1 12.59	(0.0)X1 56.26	1028.50
(-1.00)X1 64424.21	(-1.00)X1 38.49	(-29.48)X1 22.27	(0.0)X1 3.56	(-2.00)X1 19.43	(-2.00)X1 5.84	(0.0)X1 12.59	(-2.00)X1 55.13	1027.13

Graphs

Although not part of the software package, various values of enrollment, staff, and productivity may be graphed to show relationships between selected values. For example, the percentage change of FTE part time faculty to balance the budget as a function of enrollment fluctuation is graphed in Figure 3.

The slope of the diagonal connecting the points can be examined to determine how much of an enrollment decline can be handled by percentage reductions in part time faculty. Moreover, if an enrollment increase is expected, one can determine how much part time faculty must be added to increase flexibility while holding full time faculty constant. Of course, other applications are possible using other data generated through the use of SEES.

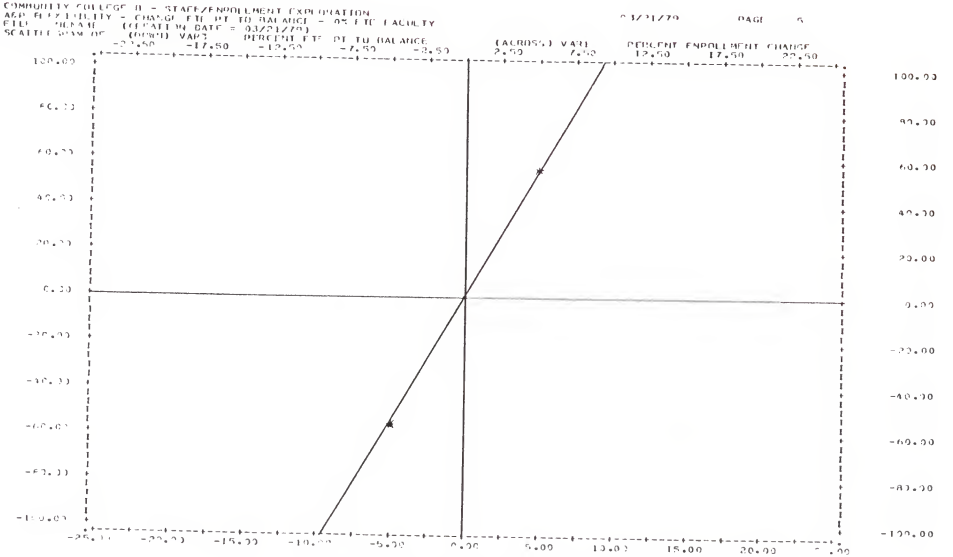


Figure 3. Percentage change in FTE part time faculty to balance the budget as a function of enrollment change.

APPENDIX B

LETTER TO INSTITUTIONAL RESEARCH OFFICERS CONCERNING MODEL EVALUATION

IRC COOPERATION FOR PROGRESS THROUGH RESEARCH
florida community junior college inter-institutional research council

April 30, 1979

Dear ,

Enclosed are two copies of an open-ended questionnaire designed to provide information to be used to evaluate Staff/Enrollment Exploration System (SEES). Would you please complete one form and forward the other to your chief finance officer or appropriate budget officer who is familiar with SEES at this time.

While there is no absolute deadline for return of the questionnaire, I hope to begin analysis of the answers by Monday, May 21.

Also, let me take this opportunity to extend my appreciation for all of your help, guidance and patience throughout the development of SEES. Truly, it could never have been done without your kind involvement!

Cordially,

Stephen W. Ritch
Graduate Research Associate, IRC

SWR:nbvo

enclosures

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EQUAL EMPLOYMENT OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER

APPENDIX C

EVALUATION OF STAFF/ENROLLMENT
EXPLORATION SYSTEM (SEES)

Responses to the following open-ended questions are being sought as a means to evaluate Staff/Enrollment Exploration System (SEES). The questions are divided into four groups on the basis of the model's performance, utility, time, and cost. This evaluation framework was adapted from generalizable criteria provided by the Academy for Educational Development (1973).

Performance

1. Does the model effectively answer questions related to cost-income flexibility?

2. Does it meet institutional needs to model cost-income flexibility?

3. How well does it relate institutional policy to cost-income flexibility?

Utility

1. How useful is the model?

2. Could it be used routinely?

3. How well would it adapt to institutional change?

Time

1. How much time is necessary for installation?

2. How much time is required for collecting the data base necessary to operate the system?

Cost

1. If you had sufficient funds and were not able to receive installation by virtue of your IRC membership, how much would you be willing to pay for SEES and its installation on your computer?

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BIOGRAPHICAL SKETCH

Stephen Wittmer Ritch was born in St. Petersburg, Florida, in 1949. He attended public schools there and graduated from Northeast High School in 1967. He was particularly active in student government and athletics.

After studying government at the College of William and Mary, where he was initiated into Sigma Nu, he attended Virginia Wesleyan College, and Graz Institute, Austria. He graduated from the University of South Florida in 1971, with a Bachelor of Arts in political science.

In early 1973, he married the former Suzanne Elizabeth Walters and returned to the University of South Florida where he earned a Master of Arts. The program involved joint study in political science and public administration with an educational component in community college curriculum and instruction. During this time he was inducted into Pi Sigma Alpha, the national political science honor society.

Shortly before completion of his Master of Arts in 1974, he was employed as an Admissions Specialist/Program Planner-Placement Specialist with Pasco-Hernando Community College. He was later promoted to the position of Acting Coordinator for Financial Aid and Veterans Affairs. While at PHCC, he was active in the state, regional, and national Associations for Student Financial Aid Administrators and was chapter vice-president of The Florida Association of Community Colleges.

In 1977, he was admitted to the Department of Educational Administration and Supervision at the University of Florida. He served as a graduate researcher with the Florida Community Junior College Inter-Institutional Research Council (IRC). During the course of his program toward the degree of Doctor of Philosophy, he became a member of Phi Delta Kappa and served as the student representative to the departmental faculty.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

James L. Wattenbarger, Chairman
Professor of Educational Administration and Supervision

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

John M. Nickens, Co-Chairman
Associate Professor of Educational Administration and Supervision

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

John H. James, Associate Professor of Management

This dissertation was submitted to the Graduate Faculty of the Department of Educational Administration and Supervision in the College of Education and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August 1979

Dean, Graduate School